Operations Manual

for the

FILMETRICS F40

Thin-Film Analyzer

Revision 7.4.0.0

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Welcome

What is the F40 used for?

The Filmetrics F40 is used to measure the thickness and optical constants (*n* and *k*) of transparent thin films. The F40 attaches to a microscope's c-mount fitting to provide a square measurement spot size as small as 1 micron. Measured films must be optically smooth and within the thickness range set by the system configuration requirements specified in **Performance Specifications**. Commonly measured films include semiconductor process films such as oxides, nitrides, resists, and polysilicon, optical coatings such as hardness and anti-reflection coatings, flat panel display films such as polyimides, resist, and cell gaps, and the various coatings used in CD and DVD manufacture. Films that cannot be measured include very rough films and opaque films.

Warning: Accurate measurements require suitable recipe settings and a valid baseline. Improper system setup or an aged lamp may also lead to errors. It is the user's responsibility to ensure that this instrument is being used properly for its intended purpose. Please contact **Filmetrics** for assistance with any questions.

Safety, Maintenance, and Care

This symbol indicates information or instructions that must be read and carefully followed to prevent hazards, injury to the operator, or damage to the instrument.

This symbol indicates a potential shock hazard. Areas marked with this symbol should be serviced by a trained service technician.

This symbol indicates that the product conforms to the WEEE (Waste in Electrical and Electronic Equipment) Directive 2002/96/EC.

CE

This symbol indicates that the product meets the applicable EU safety, health and environmental protection directive requirements.

This label indicates the Model Number and Serial Number of the instrument. This information may be necessary when contacting Filmetrics for assistance.

Disclaimer: Use of this instrument in a manner inconsistent with the information and directions included in this manual may impair the protections designed into the product resulting in danger to the operator or damage to the instrument

Installation Location: When deciding on a location for the instrument, ensure that the instrument in installed in a well-ventilated location. Enclosing the unit, or blocking the vent holes, may impair the performance of the instrument of damage the internal components.

Cleaning: The need for periodic cleaning of the system is based on the cleanliness of the environment in which the system is installed. Only the external surfaces are to be cleaned. Cleaning and maintenance of all internal components is to be performed by a trained service technician. Do not use aerosol, or spray, cleaners as they may contaminate the sensitive optical surfaces on the instrument.

Before performing any service on the instrument ensure that the main power is disconnected.

Cleanroom, or low lint, wipes should be used to wipe down the system. A mixture of Isopropyl Alcohol (IPA) and De-ionized Water (DI H2O) at 70% DI H2O: 30% IPA is to be used for cleaning. Undiluted IPA may be used, if the 70:30 DI and IPA mixture is not available, but extra care must be taken. Avoid using stronger solvents, such as acetone, as these may compromise the surface finish.

Avoid excessive pressure on any surface when cleaning. Excessive force may bend a component, which would damage the system, or cause the system to be out of alignment.

Start with the top of the system and work down. Use slow motions, in a straight line, from the back to the front of the surface being cleaned. Change the cleaning wipe periodically to avoid re-depositing material back onto the surface being cleaned. Allow all cleaned surfaces to dry completely before restoring power to the system.

CE Mandated Warnings

Please read the following instructions carefully to prevent potential shock or fire hazards. This manual should be retained for future use

Bitte lesen Sie die nachstehende Anleitung sorgfältig durch um Stromschlag und Feuergefahr zu vermeiden. Diese Betriebsanleitung sollte für späteren Gebrauch sorgfältig aufbewahrt werden.

Preghiamo di leggere accuratamente, le sequenti Instruzioni, per evitare Prossiomi Incendi e Correnti.

Shock Hazard - Do Not Enter
Achtung Hochspannung - Nicht Berühren
Attenzione Corrent-Forte - Prego non toccare

The front panel's switch is not the power disconnect device. The power cord should be removed after use.
Der Kippschalter an der Vorderseite unterbricht nicht die Stromzuführung. Das Stromkabel sollte nach Gebrauch aus dem Gerät herausgezogen werden.
L'interutore nella parete frontale non blocca le Corrente. La Corrente viene.

Never expose the unit to water or liquids. Avoid direct sun.
Bringe das Gerät nicht mit Wasser oder einer anderen Flüssigkeiten in Berührung. Vermeide direkte Sonneneinstrahlung.
Evitare contatto con acqua oppure liquidi Infiammabili al Macchineggio. Auche entrate di Sole.

Do not insert any objects into the unit.
Keinen Gegenstand in das Gerät einbringen. Do non inseriamo any obietta into gli unità.
Non mettere ogetti dentro la Macchina.

Do not use near open flame or heat.
Das Gerät nicht in der Nähe einer offenen Flamme oder Hitze benutzen.
Non mettere la Macchina vicino a fuochi oppure Riscaldamenti.

The unit should never be enclosed or blocked.
Das Gerät darf nicht eingeschlossen oder blockiert werden.
La Macchina non chinderla per nessun motivo.

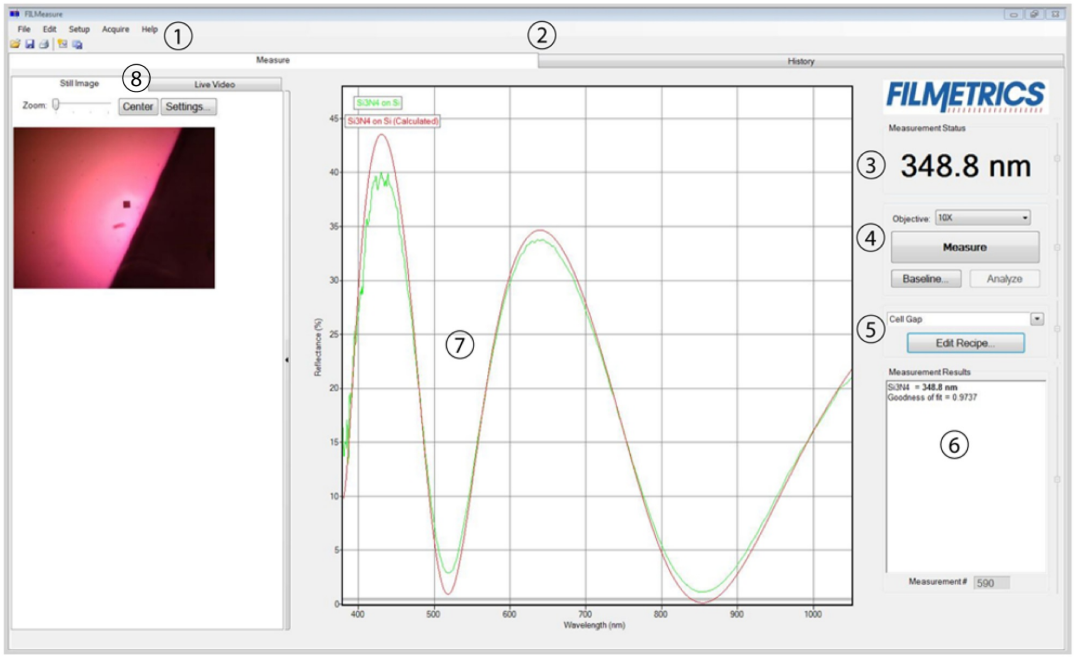
Connect unit only to a properly measured supply. Use only the three wire cord which is provided with the unit.
Schließen Sie das Gerät nur an eine ordnungsgemäss vermessene Stromsversorgung an. Verwende nur ein dreiadriges Kabel, wie es auch mit dem Gerät ausgeliefert wird.
Montare solo con misura normata. Adoperando solo 3 cavi elettrici cosi come e fornita la Macchina.

Software Overview

The way that light reflects off a thin film is determined by the characteristics of the film, such as its thickness, optical constants, and roughness. The F40 is able to determine thin-film characteristics by first carefully measuring the amount of light reflected from the thin film over a range of wavelengths (i.e., by measuring the reflectance spectrum), and then analyzing this data by comparing it to a series of calculated reflectance spectra. Most of the features of the FILMeasure software that runs the F40 can be divided into reflectance acquisition and reflectance analysis functions. The following pages outline the main features of the FILMeasure software.

The basic steps for any F40 measurement are selecting and editing the film structure, taking a baseline measurement, and then making and evaluating the measurement. The details of each of these steps are explained below, followed by descriptions of other FILMeasure functions.

Measure Tab



1. Standard Windows menus, including; **File**, **Edit**, **Setup**, **Acquire**, and **Help.**

2. These tabs are used to select between the **Measure** and **History** windows.

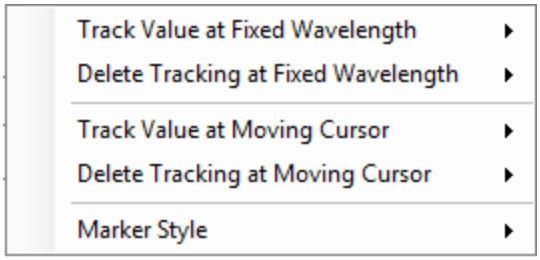
3. Displays the thickness of the film being solved for, as well as whether a sample is good or bad based on the settings in the **Alarms** tab.

4. Allows the user to **Measure** a sample, **Baseline** the system, or **Analyze** an open spectrum.

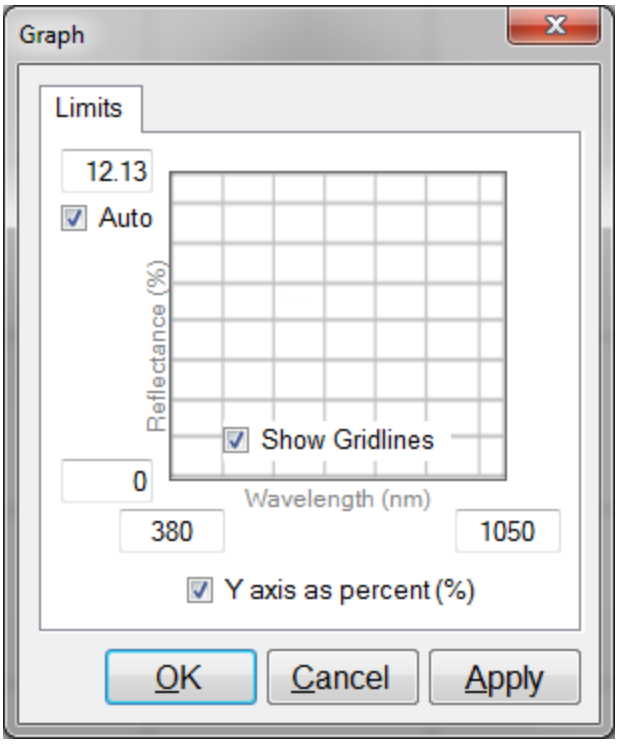
5. Users may select saved recipes from the drop-down list, or open the **Edit Recipe** dialog box.

6. This box provides more details about the calculated thickness, as well as any additional parameters that were solved for, including **Roughness**, *n* and *k*, and **Nonuniformity** as well as the **Goodness of Fit (GOF).**

7. Graphical display for spectra. A click of the right mouse button while the cursor is within the graphical display opens the below menu for easy reading of cursor values in the main FILMeasure window. The keyboard up/down and right/left arrows move the marker to a desired location.


Track Value at Fixed Wavelength
Delete Tracking at Fixed Wavelength
Track Value at Moving Cursor
Delete Tracking at Moving Cursor
Marker Style

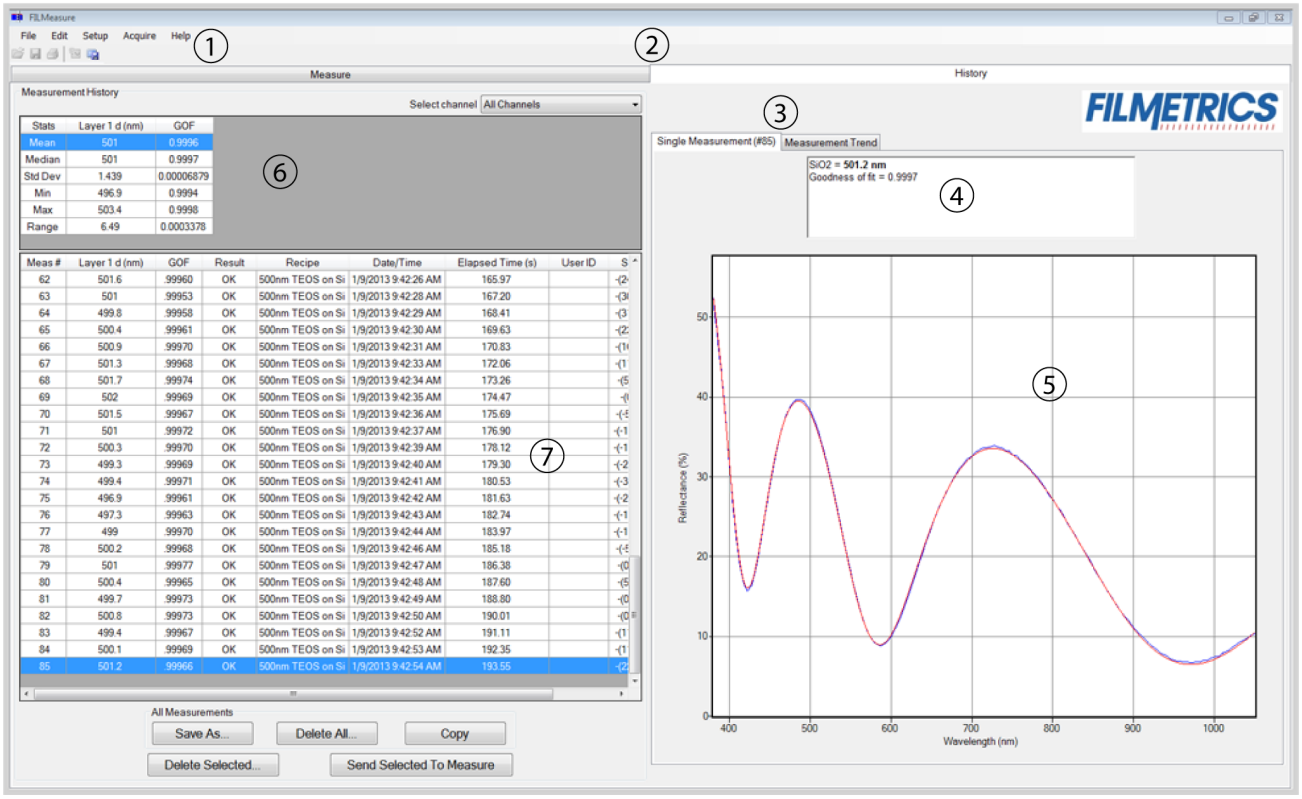
The graph limits can be changed by double-clicking on the graph display. The text boxes along the bottom of the graph control the wavelength range, in nanometers, displayed on the screen. The two on the left represent the Reflectance (%) range, with the max being set in the upper box and the min being set in the lower. The boxes on the right are for Transmittance (%). Check the **Auto** checkbox to activate y-axis autoscaling. The lower value is always 0 for autoscaling; the maximum y-axis upper limit is 5000. The axes can be set to display in percent or as a decimal value (100% = 1).



Graph Options can be accessed and edited by double-clicking on the main graph window.

8. Controls and settings for the camera are available here.

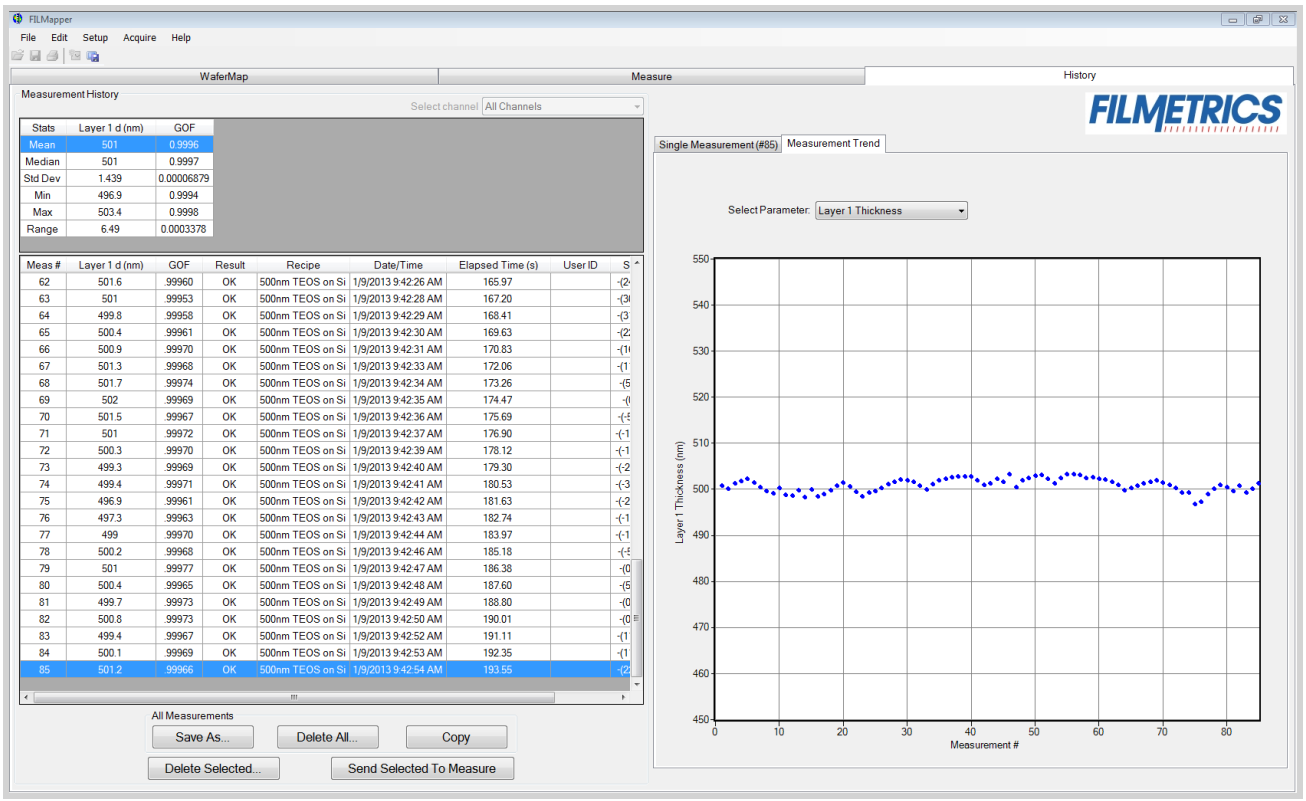
History Tab



1. Standard Windows menus, including; **File**, **Edit**, **Setup**, **Acquire**, and **Help.**

2. These tabs are used to select between the **Measure** and **History** windows.

3. Used to alternate between the **Single Measurement** and **Measurement Trend** tab. Selecting the **Measurement Trend** tab will allow the user to see a plot of the measurement results versus measurement number.



When the **Measurement Trend** tab is selected in the **History** window, the right side of the screens graphs the results.

4. Shows the measurement results for the selected spectrum (must be in **Single Measurement** mode).

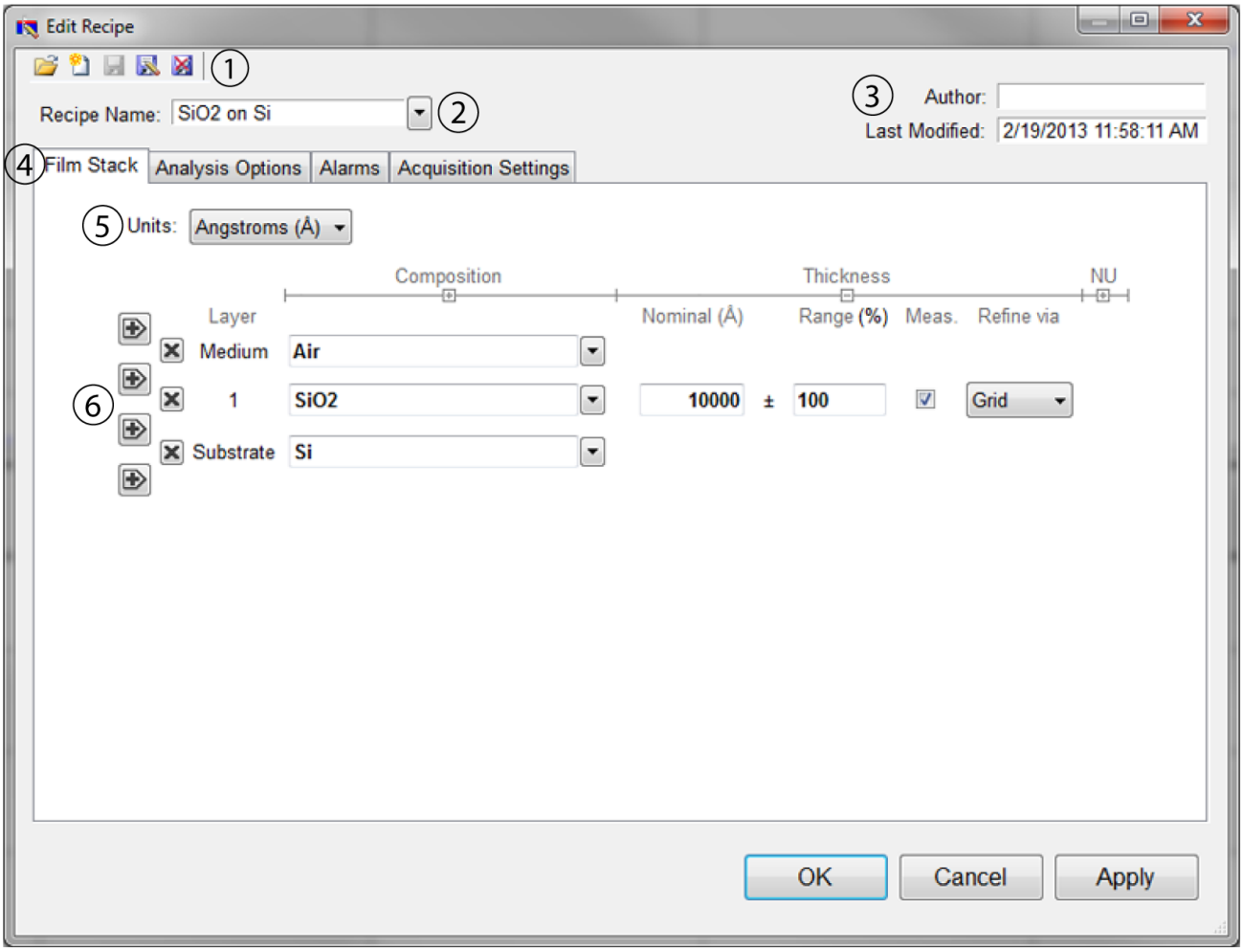
5. Displays the selected spectrum (in **Single Measurement** mode).

6. Displays statistics for all measurements included in the history file.

7. This list contains all spectra currently included in the history file. Right clicking anywhere is this box will allow the user to open the **Edit Columns** control panel.

Edit Recipe Window

The **Edit Recipe** window is used to define the film stack and to set analysis and acquisition parameters.



1. These buttons allow you to, in order from left to right:
    i. Open a saved recipe.
    ii. Start a new recipe.
    iii. Save the current settings.
    iv. Save the current settings as new recipe
    v. Delete the current recipe.

2. Opens a drop-down list for quick access to saved recipes.

3. **Author**, as defined by user login name and recipe modification date is indicated here.

4. Allows the user to select between the **Film Stack**, **Analysis Options**, **Alarms**, and **Acquisition Settings** tabs.

5. The desired thickness units are chosen here. The choices include angstroms (Å, $10e^{-10}$ m), nanometers (nm, $10e^{-9}$ m), kilo-angstroms (kÅ, $10e^{-7}$ m), microns (µm, $10e^{-6}$ m), microinches, mils, millimeters (mm, $10e^{-3}$ m), and **Custom Units**.

6. This is where the materials and parameters to be solved are defined.

Editing Film Recipes

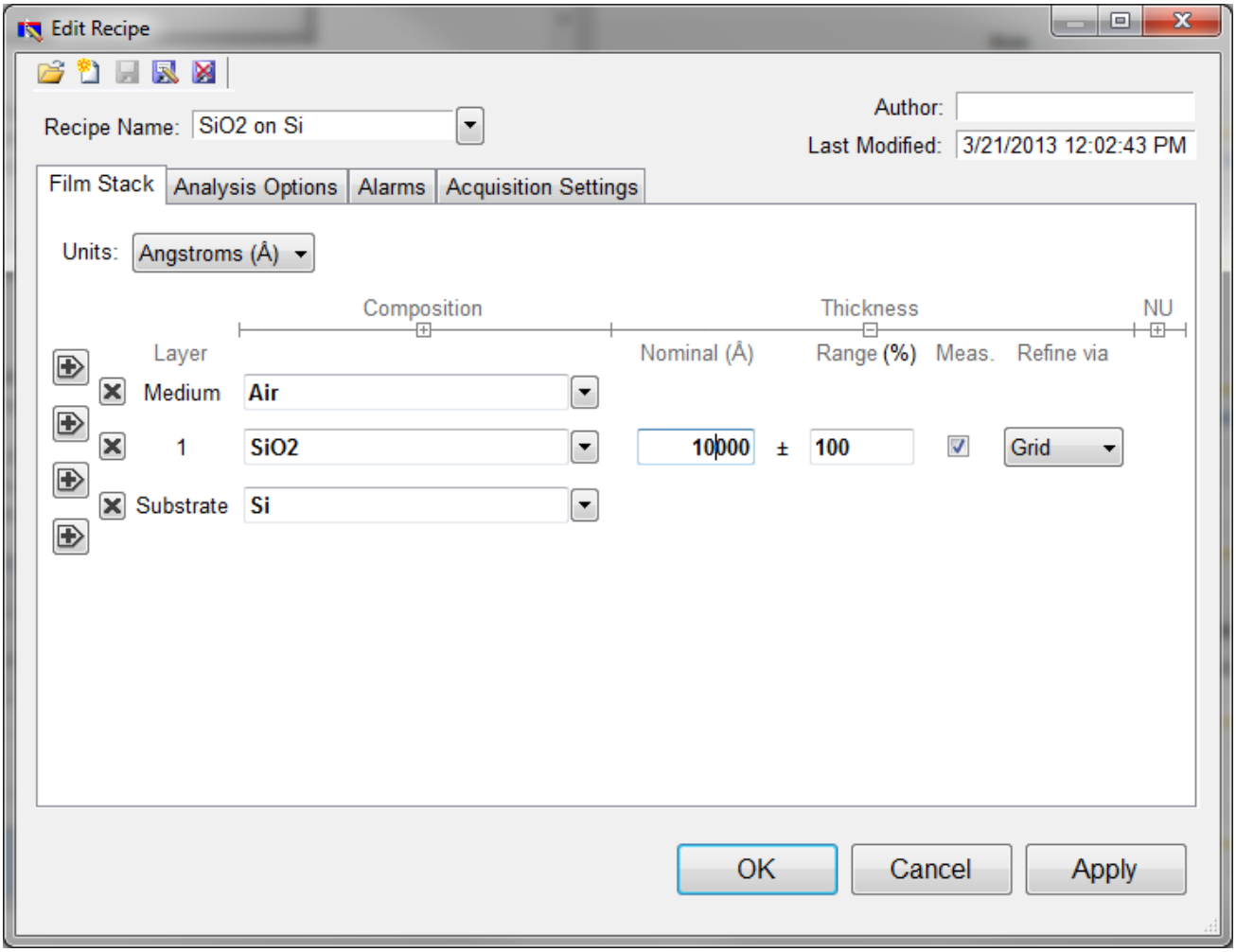
The description of the nominal film structure, as well as the measurement parameters, is specified in the **Edit Recipe** dialog box. Hundreds of different film structures and their measurement specifications may be saved.

The **Edit Recipe** dialog box is accessed with the **Edit Recipe...** button on the **Measure Tab**. The **Edit Recipe** dialog box lists an initial guess at the specifications of the film structure to be measured. These specifications include the number of films in the structure, the specifications of individual films (thickness and index), and the film parameters to be measured.

Adding, Changing, or Deleting a Structure

When the **Edit Recipe** dialog box is opened, it shows the stored specifications of the structure selected from the **Recipe:** list, along with any changes made since the recipe was loaded. Changes to the structure selected can be permanently stored by making the desired changes and then clicking on **Save**. New structures may be added to the **Recipe:** list by clicking on **Save As**. Similarly, a structure may be deleted (removed from the **Recipe:** list) by clicking on the **Delete** button.

Film Stack



The **Film Stack** tab is used to define the film structure and desired measurement units, as well as the starting guesses and constraints for thickness, *n* and *k*. This is also where you determine your analysis method, **Grid**, **FFT**, or **None**, as well as any **Nonuniformity** that may be present in the sample. The [+] and [-] above **Composition**, **Thickness** and **Nonuniformity** can be used to expand or hide solving options.

Setting Up a Film Stack

When measuring a layer, the specifications (thickness, *n*, and *k*) of the known films (including the incident medium and substrate) must be entered into the proper fields in the **Edit Recipe** dialog box, as well as initial guesses for the values to be measured. The refractive index (*n*) and extinction coefficient (*k*) values for common materials can be selected from the drop-down menus on the right-hand side of the listed materials, or by left-clicking on the material and using the **Search** function. Note that if a generic index is selected, the software will instead prompt for a new index value.

If a material is being measured is not present in the material library there are three possible approaches to complete the recipe:

a) Choose a material in the library that is similar.
b) If the material is transparent (an insulator), select **"Enter Refractive Index Value"** from the material list and enter a value for the refractive index (*n* will automatically be varied by FILMeasure to account for dispersion effects, with the entered value being *n* at 632.8 nm).
c) Create a new material file using the **Edit>Material Library...** dialog box. Enter the refractive index values for *n* and *k* as a function of wavelength and save the files so that they may be selected as in the recipe. See **Creating and Editing *n* and *k* Files** for more information.

Choosing the Films to be Measured

To measure a film's thickness, check the **Meas** box on the right-hand side of the **Thickness** field under the **Film Stack** tab in the **Edit Recipe** dialog box. When no boxes are checked, the theoretical spectrum for the specified layer stack and thicknesses will be displayed.

As with most measurements, the uncertainty of the measured data increases as the number of simultaneously measured values increases. Thus it is best to provide as much information about the film structure as possible.

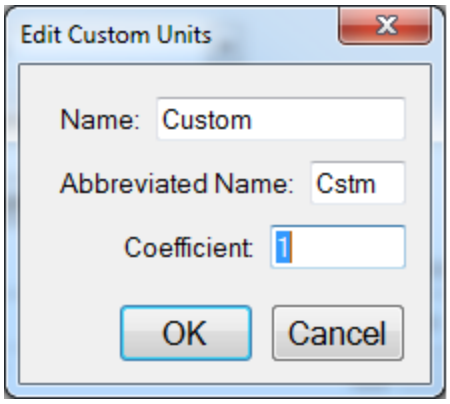
Constraints

By setting constraints, the user can limit the possible values of the measured film properties. The constraints are set in conjunction with the values entered in the **Range** dialog box for **Thickness**. For example, if the initial guess of the measured thickness of a film is 100 nm and the thickness constraint is set at 50%, FILMeasure will only consider possible thicknesses in the range 50 nm to 150 nm. The constraints for *n* and *k* are set using the *n* and *k* dialog boxes under **Composition**. These boxes are only visible when the **Thickness** and **Composition** options are expanded.

You can select between constraining by a percent of the thickness guess, or by a selected thickness by clicking on the % or measurement unit above the constraints dialog box. Constraining the measurement range can speed up analysis and can also help exclude non-physical solutions.

Custom Units

The **Custom Unit** function allows you to create your own custom unit for measurements if the metric you'd like isn't already available in the drop-down list.



The **Edit Custom Units** dialog box.

To determine the correct coefficient to use, you must first know the relationship between your unit and nanometers. For example, if your units are mg/ft^2 and it's been determined that 1 mg/ft^2 works out to a film thickness of 150 nm, then you would calculate your coefficient as follows, where X is the coefficient.

$$1\frac{mg}{ft^2} * X\frac{nm}{\frac{mg}{ft^2}} = 150nm$$

$$Xnm = \frac{150nm}{1nm}$$

$$X = 150$$

Custom units can be saved as part of the **Recipe** file, and only one custom unit can be saved per recipe.

nk Model

When measuring the *n* and *k* of a film, the general dependence of these values upon wavelength must be specified. This dependence is determined by the type of material to be measured. For example, insulators, semiconductors, and metals all have a unique type of *n* and *k* wavelength dependence.

Dozens of models for these different dependencies have been proposed and used over the years. FILMeasure uses a few of the most versatile and accepted models. For insulators the Cauchy model is used, for semiconductors either the Amorphous or Bridge-Lorentzian model, and for metals the Drude model.

There are also a number of special-purpose models for specific applications. These models, and starting coefficients values, are selected automatically when a material is chosen from the **Material** lists in the **Edit Recipe** dialog box. Other models may also be specified by selecting them from the ***nk* Model** drop-down menu under the **Composition** tab which is accessed by right clicking on the **Meas** checkbox when solving for optical constants is enabled.

Grid Search for Thickness

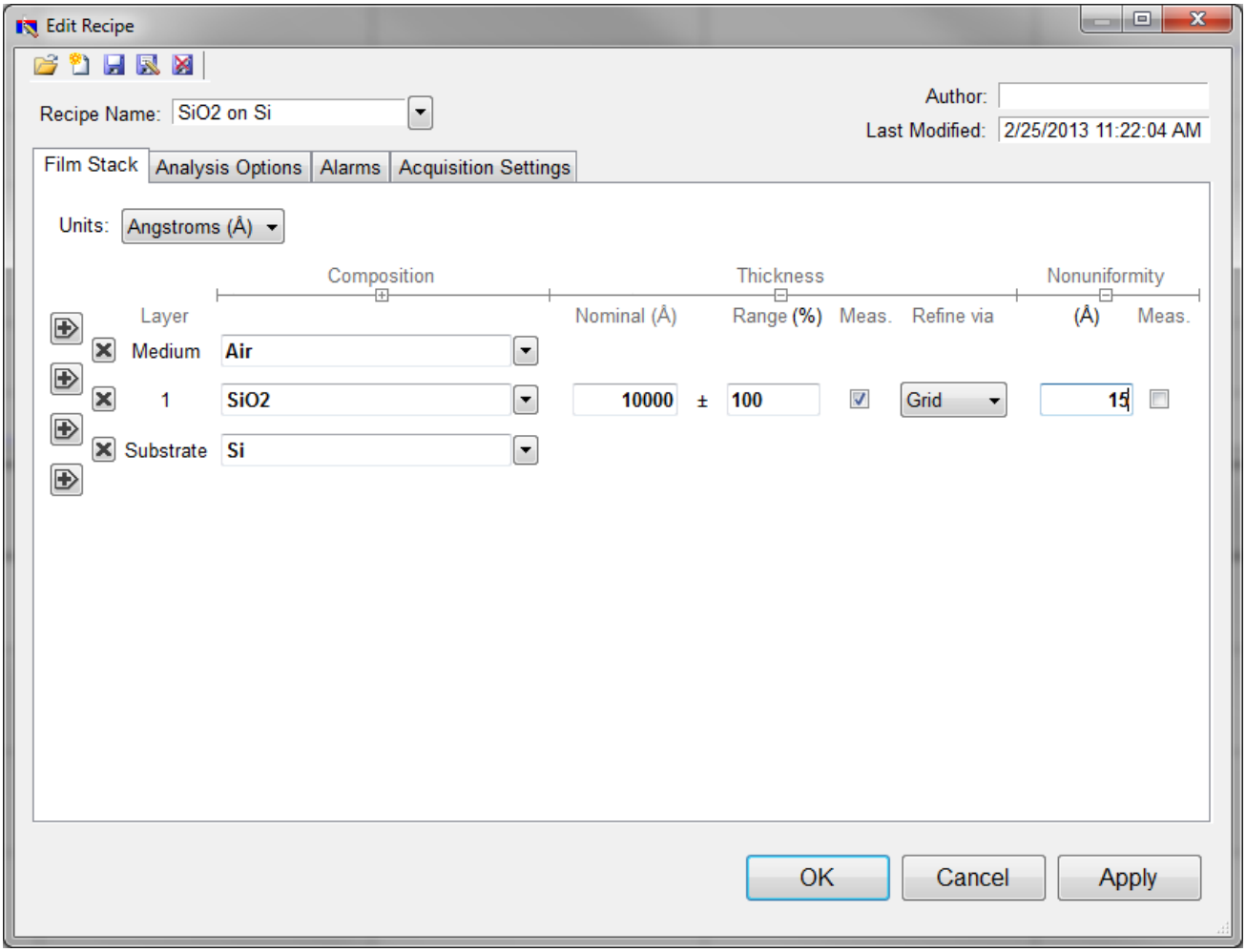
There are a number of methods that FILMeasure can use to determine thickness. Each is a different trade-off between speed, accuracy, and robustness (i.e., the ability to find the best solution among many that are nearly as good). Because thickness can vary over many orders of magnitude and many near-solutions may exist, it is often best to use a very robust method to get close to the best solution, and then let a more accurate method take over.

One very robust method is the **Grid** method, which can be activated by selecting the **Grid** option in the **Refine via** drop-down menu. The **Grid** method searches the entire allowed thickness range (as defined by the initial guess and the constraints) to find the best initial thickness. However, on some very complex multilayer spectra, it is possible for the Grid method to give the wrong answer. In such cases it is best to use the **Fourier Transform(FFT)** method to determine initial thicknesses, or to provide them manually.

Fourier Search for Thickness

The **FFT** option in the **Refine via** drop-down list is an alternative option to let FILMeasure choose an initial thickness for analysis. The Fourier Transform method analyzes the oscillations present in the spectrum and determines the film thicknesses based on the periodicity of those oscillations. It is generally somewhat less robust than the **Grid** method, but is better at finding the correct thickness in cases where the shape of the initial theoretical spectrum is different than the measured data (i.e., the reflectance spectrum is non-ideal in some way) or occasionally in cases where there is more than one film thickness is being measured.

Nonuniformity

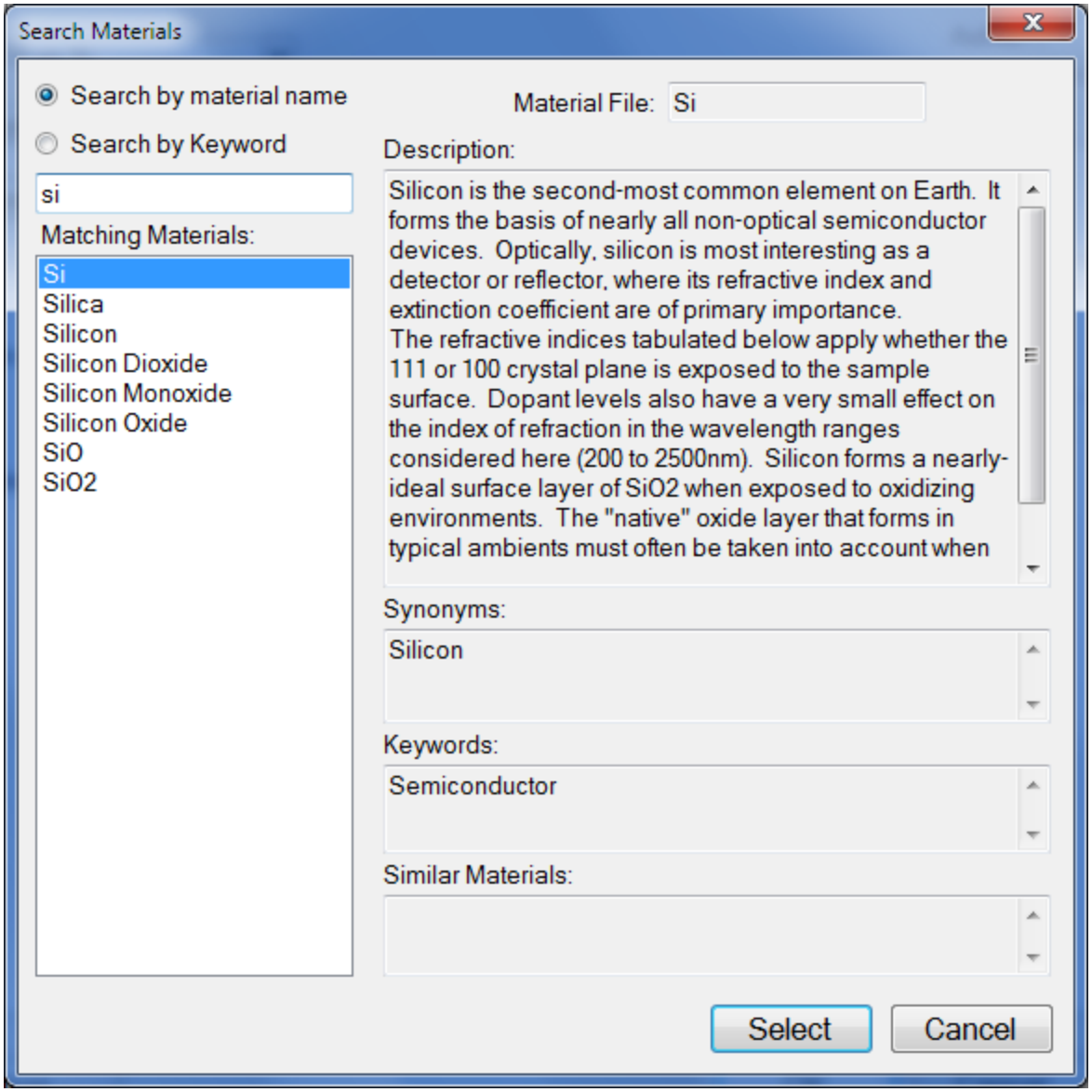


The **Edit Recipe > Film Stack** tab with the **Nonuniformity** option expanded.

Selecting this option enables modeling of thickness nonuniformity within the measurement spot. An initial guess for **Nonuniformity** must first be made, and then solving can be enabled or disabled by toggling the **Meas** box. If solving is not enabled, the software will assume the value provided for nonuniformity.

Note: Solving for nonuniformity can greatly increase solving time.

Search


Search Materials
Search by material name
Search by Keyword
si
Matching Materials:
Si
Silica
Silicon
Silicon Dioxide
Silicon Monoxide
Silicon Oxide
SiO
SiO2
Material File: Si
Description:
Silicon is the second-most common element on Earth. It forms the basis of nearly all non-optical semiconductor devices. Optically, silicon is most interesting as a detector or reflector, where its refractive index and extinction coefficient are of primary importance.
The refractive indices tabulated below apply whether the 111 or 100 crystal plane is exposed to the sample surface. Dopant levels also have a very small effect on the index of refraction in the wavelength ranges considered here (200 to 2500nm). Silicon forms a nearly-ideal surface layer of SiO2 when exposed to oxidizing environments. The "native" oxide layer that forms in typical ambients must often be taken into account when
Synonyms:
Silicon
Keywords:
Semiconductor
Similar Materials:
Select
Cancel

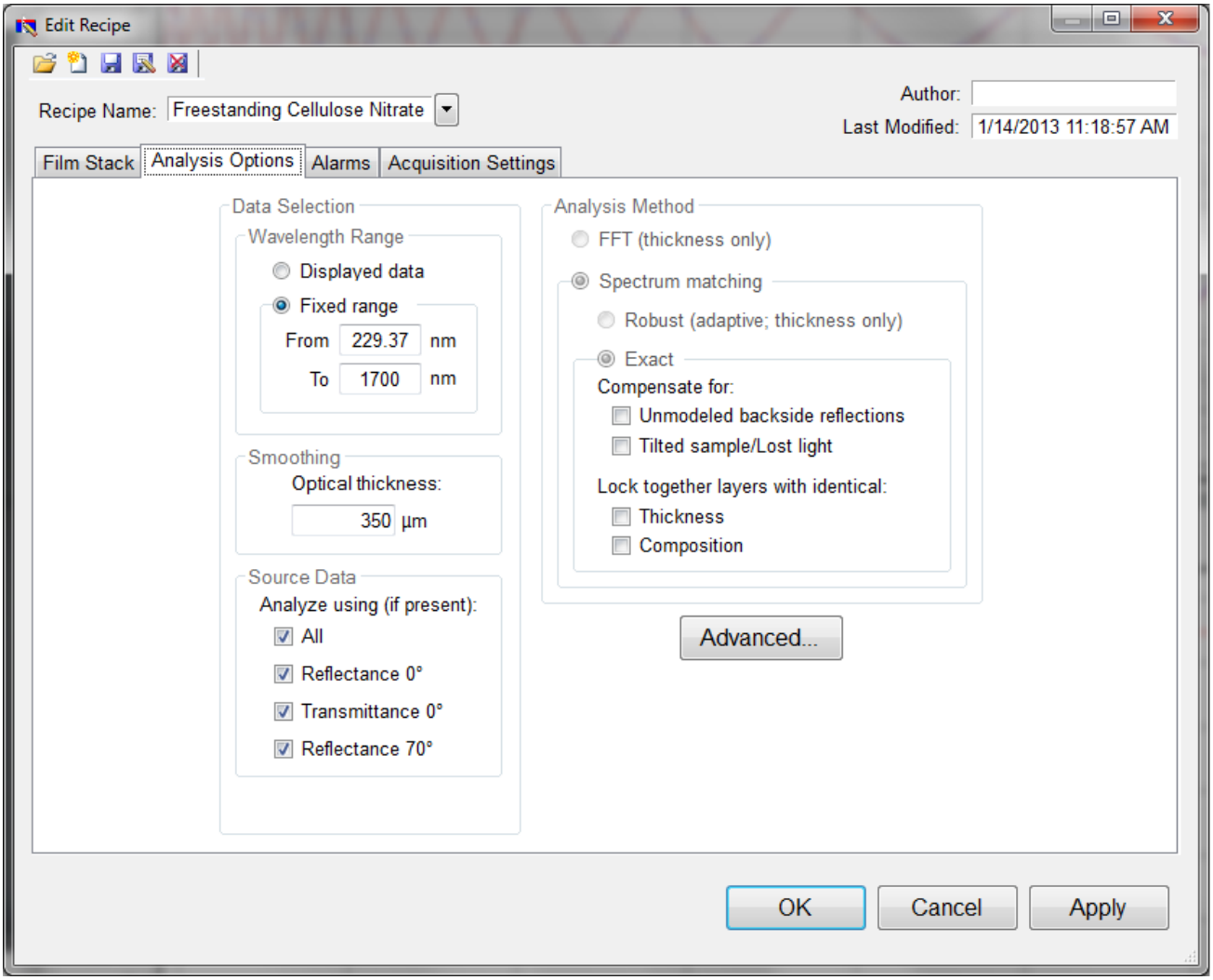
The **Search Materials** dialog box is accessible by left-clicking on a material name in the **Edit Recipe > Film Stack** tab, or by selecting **Search...** from the material selection drop-down list.

Note: When clicking on a generic index file, the software will instead provide you with a dialog to enter a new index value.

This feature allows the user to search for materials by using either the material name, or a keyword for a certain class of materials. The search function will also show a brief **Description** of the material selected, as well as any **Synonyms** or **Keywords** related to the material file. When files have a **Synonym**, that means they are referencing the same material file under different names. So for example, if Silicon is

selected the file that will be shown in the **Film Stack** is Si, not Silicon, as that is the file both names are referencing. The **Similar Materials** box will list any materials that may have similar optical properties.

Analysis Options



Correct setting of the following options will help ensure accurate measurements. Many of the options are set automatically when film information is supplied in the **Edit Recipe** dialog box, and all of them can be saved so that subsequent measurements can be made as quickly and easily as possible. If **Robust (Adaptive; Thickness Only)** or **FFT (Thickness Only)** is checked, only the **Data Selection** settings will be accessible.

Data Selection

Wavelength Range

This sets the wavelength range that is to be analyzed. It may be set as either the entire range displayed on the graph or a fixed range as defined by the user. Wavelength range may also be changed by clicking and dragging the ends of the gray bar near the bottom of the graph area in the main FILMeasure

window. Moving the bar will cause the software to reanalyze the data in the newly selected wavelength range.

Smoothing

This function performs wavelength-dependent boxcar averaging on the measured spectra. This can improve signal-to-noise levels and can filter out oscillations that correspond to optical thicknesses (defined as thickness * refractive index) equal or greater than the specified value. This value should be lowered to increase smoothing, and raised to decrease smoothing. To eliminate smoothing, a very high value (for example, 1000 µm) should be entered.

Source Data

If more than one data set is present, this option tells the software whether to analyze the 0 degree reflectance data, transmittance data, 70 degree reflectance data, or some combination of the three.

*Note: While every Filmetrics system is capable of opening and analyzing spectra with 70 degree reflectance data, only the **F10-RTA** is capable of collecting this data.*

Enable FFT (Thickness Only)

The **FFT (thickness only)** solver is one of three analysis methods available in the FILMeasure software.

This solver best suited for films greater than 250 nm thick, as well as multi-layered films. It is also an effective option when the index of refraction of the film isn't well known. While this feature is selected there will be fewer options under the **Analysis Options** tab. You cannot solve for index, roughness, or nonuniformity with the **FFT (thickness only)** solver enabled. More information on the solver can be found **here**.

Enable Robust (Adaptive; Thickness Only)

The **Robust (adaptive; thickness only)** solver is the second of three analysis methods available within FILMeasure. It is best suited for measuring the thickness of single-layer films greater than 150 nm thick.

This method can oftentimes successfully measure films when the data is affected by non-ideal properties, such as thickness nonuniformity, grading, and birefringence. Much like the **FFT (thickness only)** solver, enabling **Robust (adaptive; thickness only)** will limit the options available in the **Analysis Options** tab. You also cannot solve for roughness, nonuniformity or index with the **Robust (adaptive; thickness only)** solver enabled.

Exact Spectrum Matching

The **Exact Spectrum Matching** is the third of three analysis methods available in FILMeasure. This solver can be used to measure thickness, thickness nonuniformity, and roughness of single and multilayer films, and can additionally solve for index.

Unmodeled Backside Reflections

When measuring films in transparent substrates, reflectance off of the backside of the substrate may occur. Selecting **Compensate for: Unmodeled backside reflections** allows the software to shift the intensity of the reflectance curve to account for the additional light. This feature should not be used when measuring very thin films (< 100 nm).

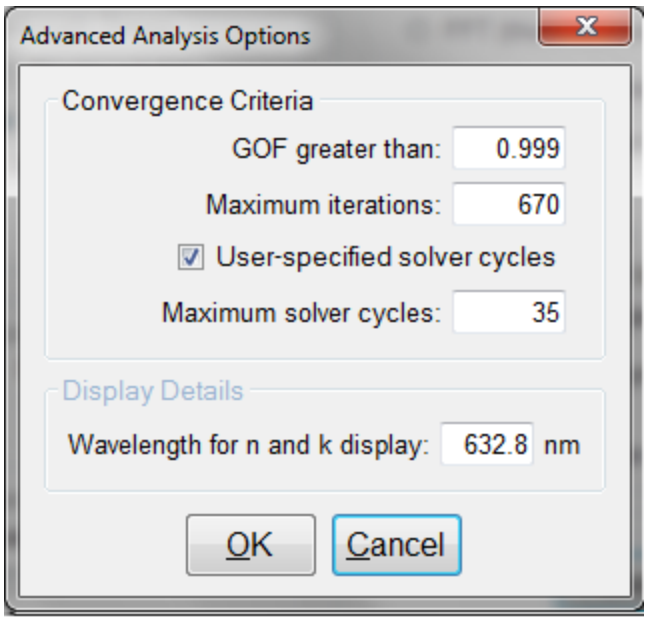
Tilted Sample/Lost Light

Samples with non-coplanar surfaces scatter some of the light away from the collection optics. This option automatically compensates for the light lost due to nonplanarity.

Lock Identical Layers

Samples comprised of repeating layers can be more accurately measured by activating this option. By activating these options, all properties of any layers that initially have the same material or thickness are locked together.

Analysis Options: Advanced



Advanced Analysis Options for Spectrum Matching.

Convergence Criteria

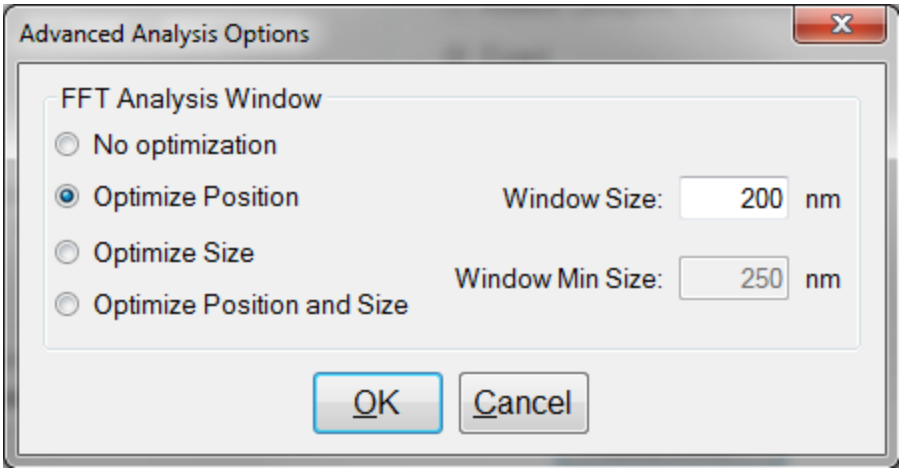
This sets the minimum **GOF** between the measured and calculated spectra that is attained before the measurement routines consider the solution final. In most cases a value of 0.999 is sufficient. For cases where the desired **GOF** is not attainable, the value in the **Maximum Iterations** field limits the number of iterations performed by the analysis routine.

Solver Cycles

This option will enable multiple solver cycles, with the number of cycles being defined by the number entered in the text box. When using this option, the software will run through the model for a solution once, and then try again starting from the solution previously found. This can help find the best solution amongst a number of near-best solutions, which can be the case when solving for a large number of parameters (several thicknesses and/or refractive index). A greater number of cycles will lead to a longer solving time, however.

Display Details

This feature controls the wavelength at which *n* and *k* are displayed in the **Measurement Details** portion of the main screen. These values are only displayed if solving for *n* or *k* is selected in the **Film Stack** tab.



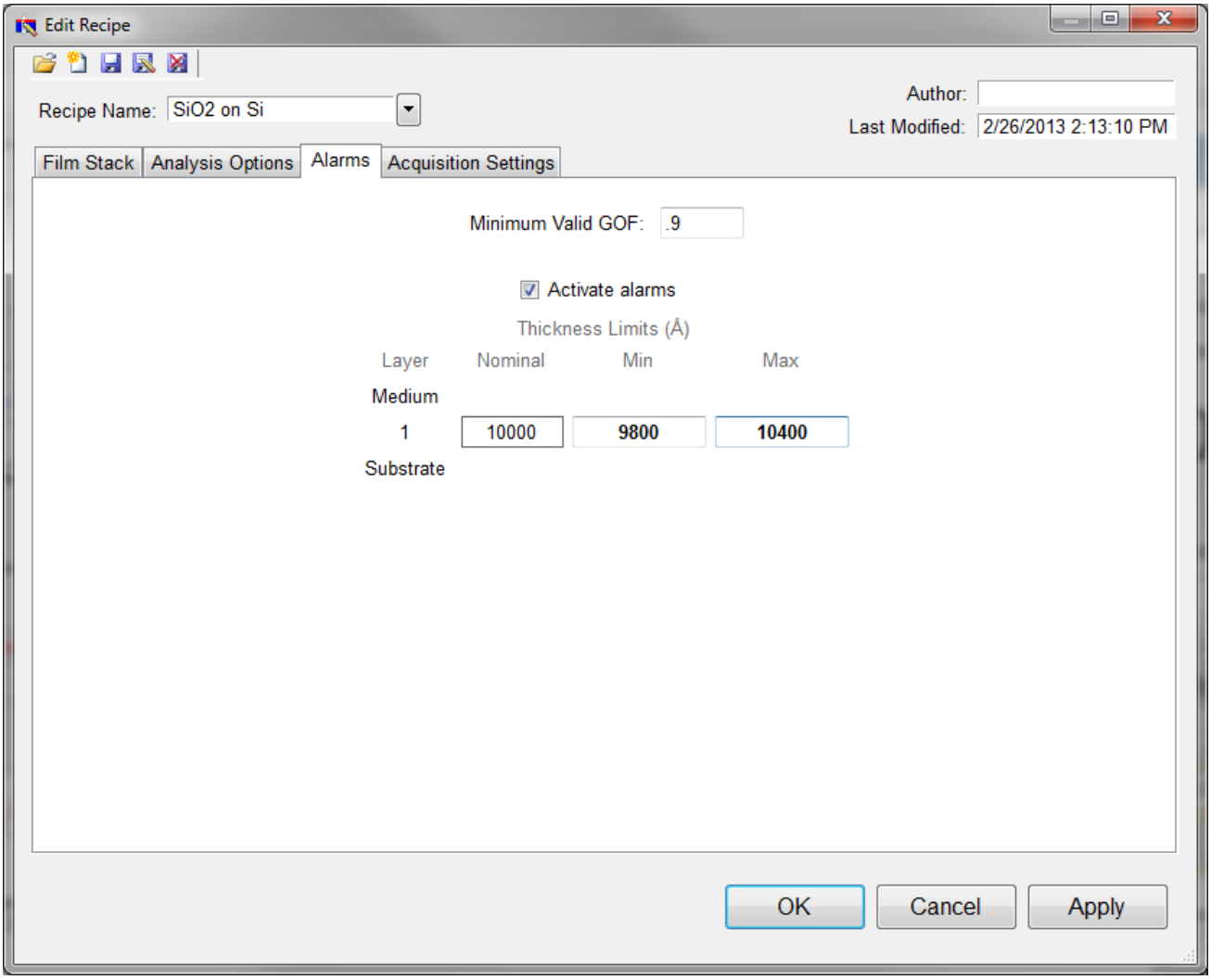
Advanced Analysis Options for FFT Analysis.

FFT Analysis Window

When the **FFT solver** is selected, the advanced options give you access to various settings to help optimize analysis performance. When **Optimize Position** is selected, the solver will check for the best possible GOF value in different areas across the spectrum in a wavelength range defined by the entered window size. For example, if a window size of 200 nm is selected, the solver will look at six different 200 nm sections of the spectrum, and then select the range the provides the best GOF.

If **Optimize Size** is selected, the solver will instead begin with a minimum window size as defined by the user. It will then start at the center of the analysis range, and then extend equally in both directions six times to find the best GOF. When **Optimize Position and Size** is selected, the software does both functions, resulting in measuring thirty-one different combinations of location and analysis range.

Alarms



Minimum Valid GOF

Constraining the **Minimum Valid GOF** will exclude measurements where the calculated **GOF** does not reach the specified limit. A warning or **"Invalid"** result will appear if the GOF constraint is not met. Specify 0 to have all solutions reported.

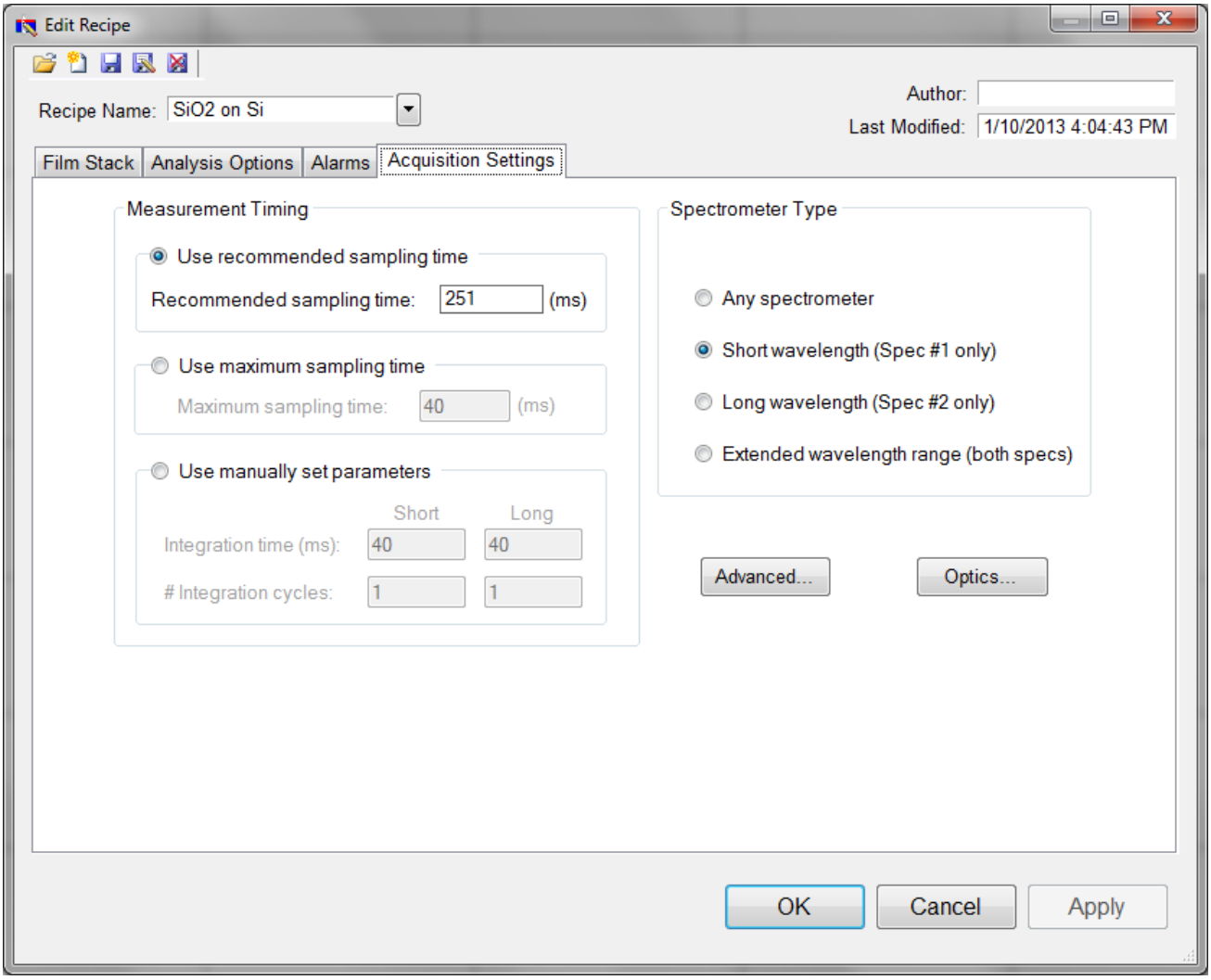
Activate Alarms

When **Activate Alarms** is selected, an alarm will trigger if the measured thickness of the sample is outside the specified **Thickness Limits**.

Thickness Limits

Setting the minimum and maximum allowable thickness limits will trigger an alarm if the measured thickness is outside the limits when **Activate Alarms** is selected.

Acquisition Settings



This menu lets the user control **Measurement Timing**, **Spectrometer Type** (on EXR and UVX systems), **Optics Configuration**, and **Advanced Acquisition Settings**.

Measurement Timing

Use Recommended Sampling Time

Selecting this option uses the sampling time that has been automatically calculated by the software during the baseline procedure. The displayed value is the total sampling time and not necessarily the integration time. To see the integration time and number of integration cycles go to the **Help > Diagnostics** menu.

Use Maximum Sampling Time

Users can set a maximum sampling time by selecting this option. By increasing sampling time the user may see a decrease in signal noise, but at the trade-off of a longer acquisition time.

Use Manually Set Parameters

Users can set the integration time per acquisition cycle and set a number of integration cycles over which to average. When using this option, the total sampling time is equal to the integration time multiplied by the number of integration cycles.

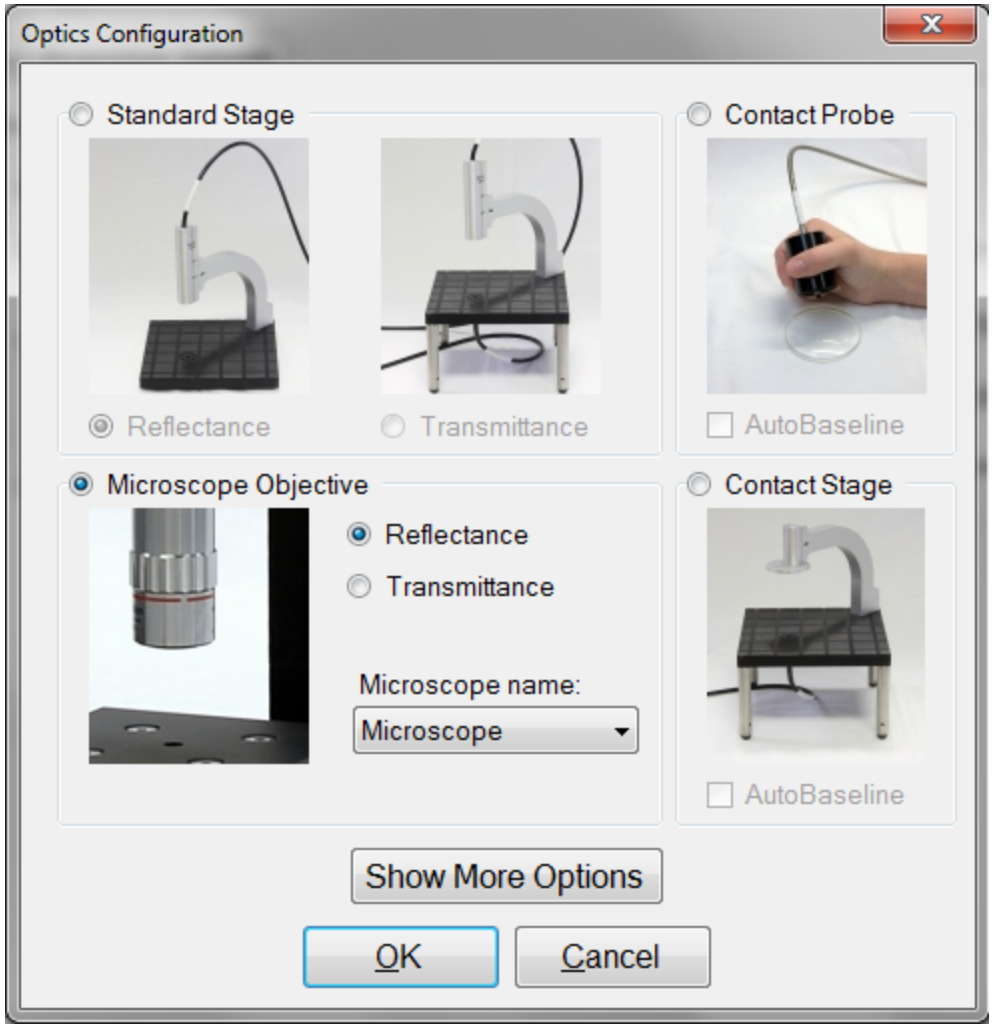
To set the integration time manually, set the sample on the stage and select **Setup>Raw Signal…** If the proper integration time is unknown, an initial value of 40ms is a good starting guess. The vertical scale of the spectrum extends from zero to 4095. Thus, a good working level is when the peak height of the sample being measured, or the reflectance standard, whichever is greater, is 3000-3500 counts. (Note: if the reference measurement saturates – Detector Saturation error – then spurious final measurements will result.) If the maximum signal is too low, increase the integration time. Too large an integration time will result in excessive dark current, so it is sometimes necessary to accept a smaller signal level to limit the dark current.

Note: If the integration time is changed, it will be necessary to perform the baseline procedure, or re-acquire the reflectance standard and background scans.

Spectrometer Type

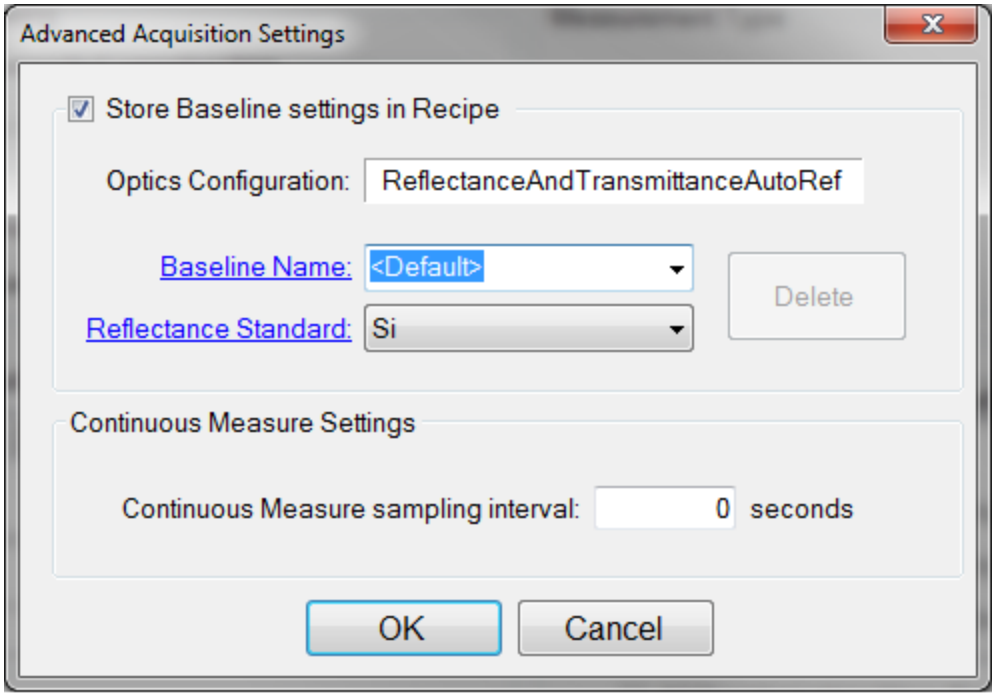
EXR and UVX systems have two spectrometers (VIS/UV and NIR). Here the user can choose to use only one or both spectrometers.

Optics Configuration



The **Optics Configuration** dialog box is accessible through the **Acquisition Settings** tab under the **Edit Recipe** window. It is important to make sure that you remember to select the proper configuration for your measurements in order to obtain the best possible results. Not all options are available with all systems.

Advanced Acquisition Settings



Store Baseline settings in Recipe

This option allows the user to save the selected **Optics Configuration**, **Baseline Name**, and **Reflectance Standard** used with each individual recipe.

Continuous Measure Settings

This option allows the user to set an interval, in seconds, between measurements when using the **Measure > Continuous Measure** command from the **Acquire Menu**. By default this is set to 0.

Understand and Evaluating Measurement Results

This section covers information on the **Display of Measured Spectra** and a more in depth look at the **Goodness Of Fit** value.

Display of Measured Data

Once film stack and measurement information have been entered and a baseline has been taken, measurements may be made by clicking on the **Measure** button. After measurement, the measured and calculated reflectance spectra are displayed on the graph. The thicknesses of the films are listed in the results box. If any of the thickness values were measured, they are displayed in bold numbers.

The quality and accuracy of the result is determined by how well the measured spectrum matches with the calculated spectrum. In general, thickness information is determined by the number of oscillations, and index information is determined by the amplitude of the oscillations. In the case of the **Robust (adaptive; thickness only)** solver and **Exact Spectrum Matching** solver, a good result is one where the minima and maxima of the measured and calculated spectrum align. For the **FFT (thickness only)** solver,

this is when the measured intensity peaks overlap. See the **Goodness of Fit** and **Troubleshooting - Thickness Modeling** sections for more information.

Goodness of Fit

The accuracy of a calculation fit, and thus the reliability of the measurement, can be judged by the match between the measured and calculated spectra, which is quantified by the GOF value. GOF is a number between 0 and 1.

A perfect match between measured and theoretical spectra will result in a GOF of 1. To ensure accurate results the user may set a minimum acceptable GOF value by entering a number between 0 and 1 into **GOF Error** on the **Alarms Tab** in the **Edit Recipe** dialog box. A warning message will be displayed after each measurement where the GOF falls below the user-specified **GOF Error**. If the GOF is less than 1 there are several possible causes as follows:

a) **Nonuniformity** – Any variation of layer thickness, or presence of roughness, within the measurement spot will result in a reduction in reflectance. In severe cases the interference peaks may disappear entirely.

b) **Incorrect Structure Definition** – If the refractive index of one or more layers in the structure is different from what is described in the layer structure, than there will be some mismatch between the blue curve and the red curve.

c) **Graded Interfaces** – The amplitude of the peaks in the spectrum depends on both the size of the change in refractive index at each interface in the layer structure and the sharpness of the interface. For example, in many hardcoat samples there is some degree of layer intermixing at the interface, leading to a weaker than expected reflectance at that interface. In severe cases the peaks may disappear entirely.

Window Menu Items

This section describes the various functions available through the standard Windows File Menus.

File Menu

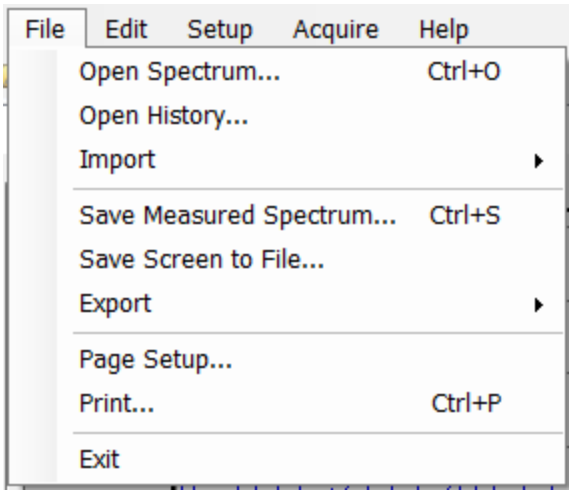
Edit Menu

Setup Menu

Acquire Menu

Help Menu

File Menu



Open Spectrum… (Measure Tab only)
This command is used to open stored reflectance spectra, which are then displayed and can be analyzed for film properties.

Open History…
Previously saved history data containing measurements and statistics can be loaded with this command.

Import: Recipe…
To import recipes that were previously exported, or created with an older version of FILMeasure, use this command.

Import: Material…
Custom materials, either created by the user or provided by Filmetrics, can be imported using this command.

Import: License…
When the user purchases an upgrade for the system, Filmetrics will send a license file to the user. The license must be imported into the software before upgrades are effective.

Save Measured Spectrum… (Measure Tab only)
This command is used to save spectra for export or later analysis. All data is saved along with the corresponding wavelength data in comma-delimited format. Files can be saved in four different formats:

*.fmspe: This file can only be opened in FILMeasure 5.0 or greater and is the preferred way to save spectra. Additional information from data acquisition is stored in this file.

*.spe: This file can be opened in all versions of FILMeasure.

*.csv: This is a comma-delimited file that can be opened directly in Excel.

*.txt: This is a tab-delimited file, and can be opened with a text editor.

Save Screen to File… (Measure Tab only)
This command takes a screenshot of the FILMeasure window.

Save *n* and *k* to files… (Measure Tab only)
This command is used to save the calculated n and k data to its own material file for use in the **Edit Recipe>Material** list boxes. All data is saved along with the corresponding wavelength data in comma-delimited format.

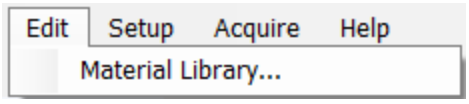
Note: This option is only present when optical constants are being solved for.

Export: Recipe…
Recipes can be exported for use on other computers running FILMeasure. The exported file will also automatically include any material files required by the recipe. To duplicate an analysis, all that is needed is the exported recipe and the spectrum being analyzed.

Export: Recipe for FILMeasure 4…
This command will convert a recipe for use with FILMeasure 4. This will not include material files or recipe features only available in FILMeasure 7.

Export: SystemInfo File…
For certain upgrade purchases that can be done through software, the user will be required to send the SystemInfo file to Filmetrics, which can be exported using this command.

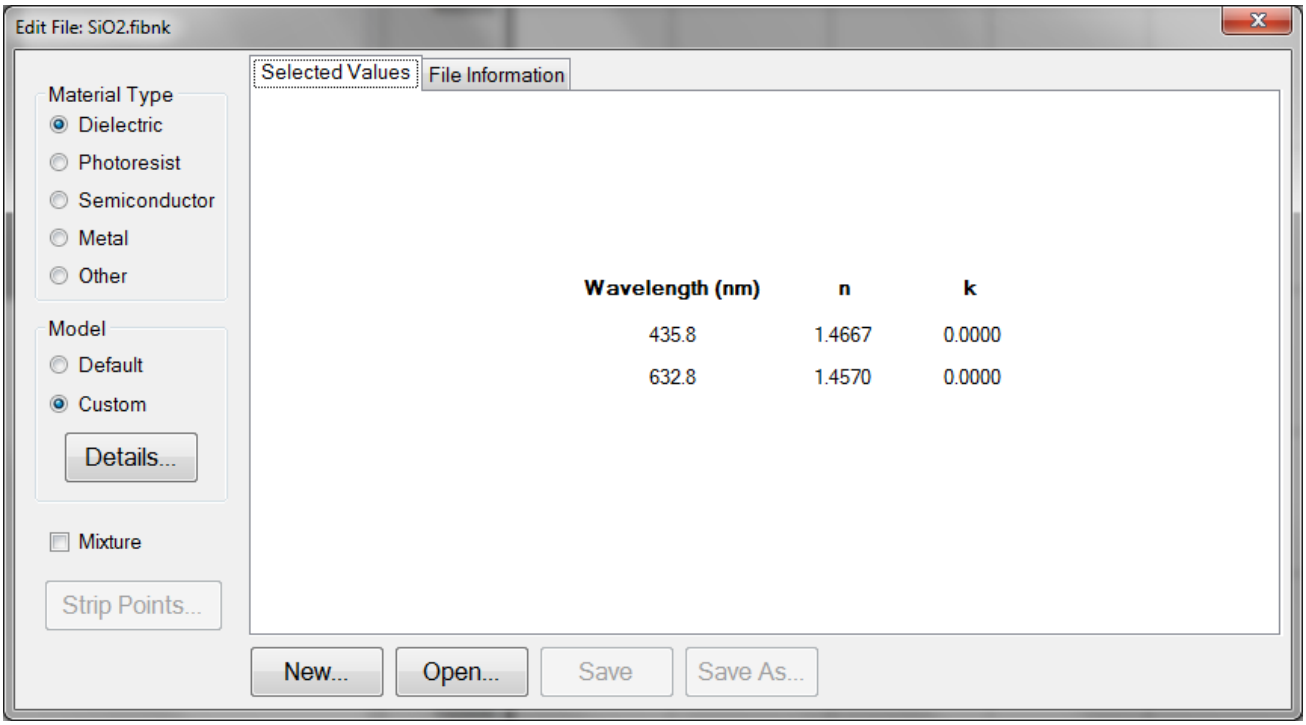
Edit Menu



This menu allows access to the **Material Library**.

Material Library

The material library is used to display information about existing materials as well as create new ones. Material files shipped with FILMeasure have the file extension ".fibnk" and will only display limited information. User created material files can be plotted on a graph or viewed in table form.



A new material may be entered into the material library manually if refractive index (*n*) and extinction coefficient (*k*) are known as a function of wavelength for the new material.

To create a new material file:

a. Select **Edit>Material Library…** menu item. The **Edit Material** dialog box will appear.

b. Click **New…** to create a new material.

c. Select the type of material you are ready to create (Dielectric, Photoresist, Semiconductor, Metal, or Other).

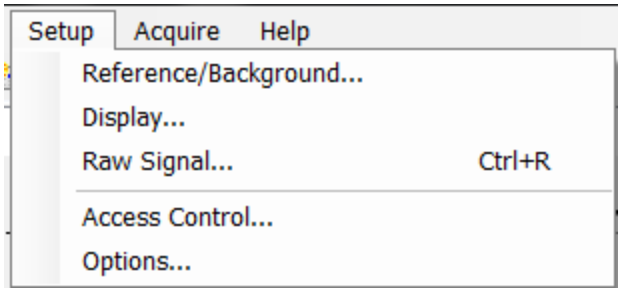
d. Optimize the functionality of the file by entering index values over the entire wavelength spectrum of the system. The wavelength unit is nanometers. Enter index information every 20 to 50 nm, depending on the complexity of the data. In areas where *n* or *k* is quickly changing, more densely spaced the points should be entered.

e. Alternatively, select the **Model>Custom** radio button and click the **Details** button. A **Custom Model Information** dialog box will appear. Select the appropriate model. Enter in the known coefficients and click **OK**. Cauchy coefficients are displayed in microns. If they are entered in Å, FILMeasure will automatically detect this and convert them to microns.

f. Click the save button to save the material. You will be asked for a file name, and you may select one of two file types:
*.fitnk: Compatible with FILMeasure 5 and beyond.

*.nnn: Creates a *.nnn file and, if there is *k* in the material, a *.kkk file to contain material data. For files with both *n* and *k*, the two files must have the same filename, xmaterial.nnn and xmaterial.kkk for example, in order for FILMeasure to properly indentify them. Compatible with FILMeasure 7 and earlier.

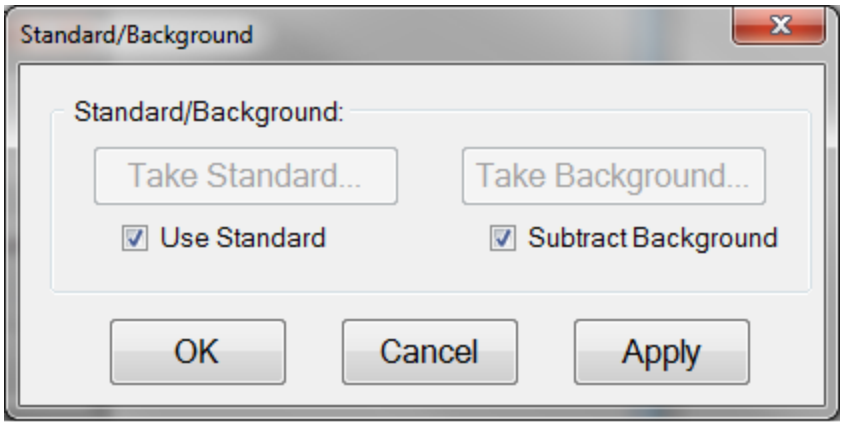
Setup Menu



This menu contains the settings for manually obtaining the **Standard/Background** information, **Display** options, and the **Raw Signal** dialog. This is also where user access can be set through the **Access Control** option, as well as modifying some system **Options**.

Standard/Background

This control is used when manually taking and enabling/disabling **Reflectance Standard** and **Background** compensation.



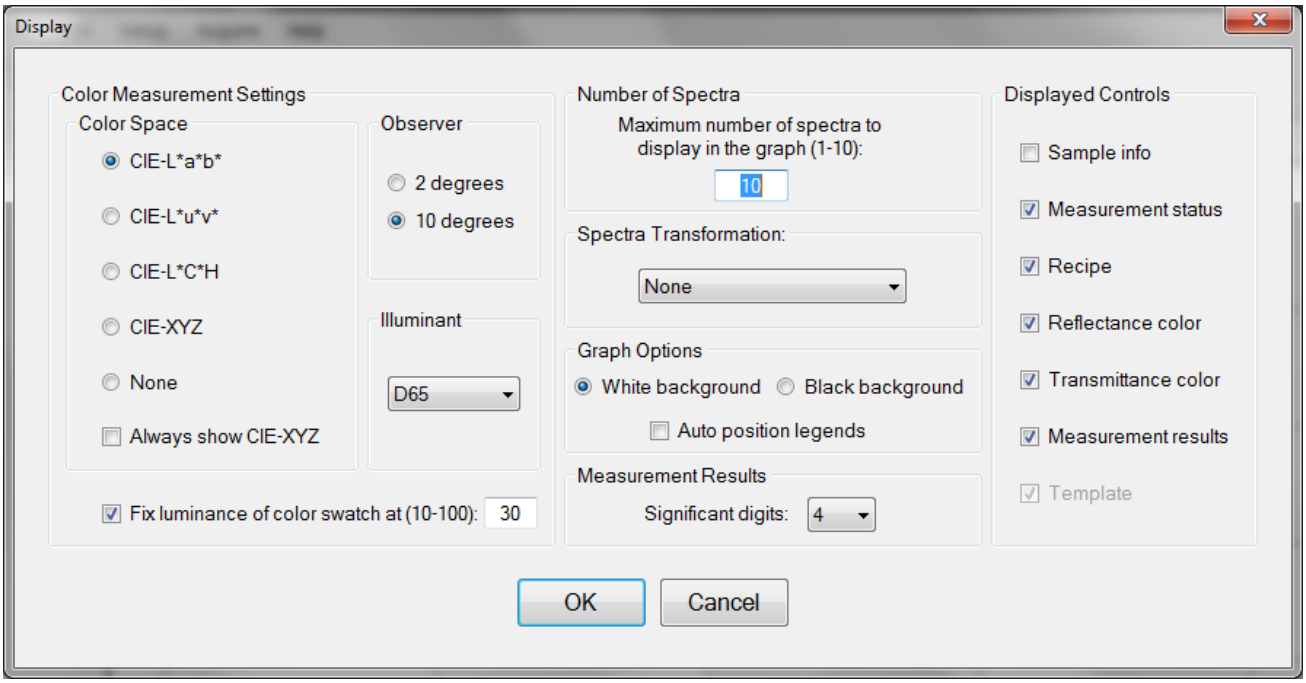
Take Standard
This button allows the reflectance standard portion of the baseline measurement to be taken without having to re-take the background measurement.

Take Background
This button allows the background portion of the baseline measurement to be taken without having to re-take the reference measurement.

Use Standard
This checkbox allows the reflectance standard portion of the baseline correction to be enabled or disabled. This box is only available if a baseline has already been completed.

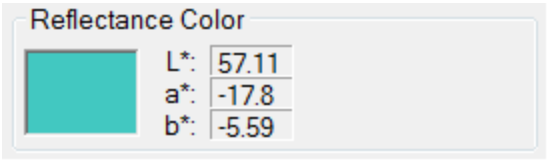
Subtract Background
This checkbox allows the background subtraction portion of the baseline correction to be enabled or disabled. This box is only available if a baseline has already been completed.

Display



Color Measurement Settings: Color Space

The color of a spectrum can be displayed and quantified on the main screen if a color space coordinate system is selected.



When a **Color Space** is selected, the color of the spectrum and the coordinates appear on the main FILMeasure window.

Color Measurement Settings: Observer

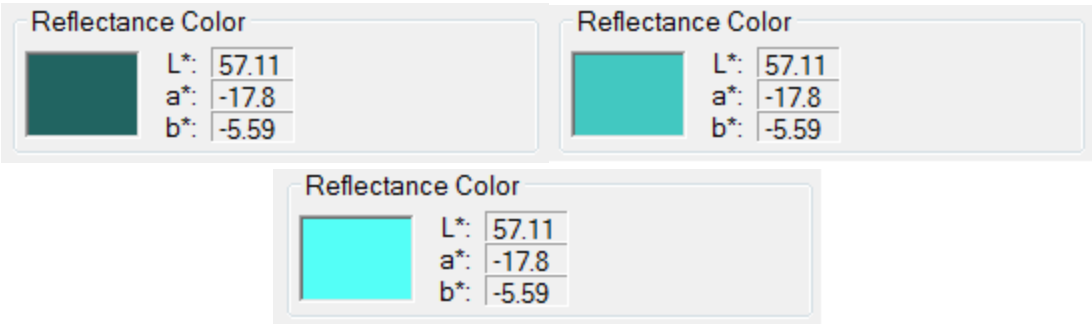
When a specific color space is chosen for display, this option allows the user to choose between the CIE 1931 2 degree observer and the CIE 1964 10 degree observer. Note that this variable is associated with the CIE eye-response convention (see, for example, **http://en.wikipedia.org/wiki/CIE_1931_color_space**) and is unrelated to the illumination or collection angle of the measurement.

Color Measurement Settings: Illuminant

This setting refers to the **standard illuminant** being used by the software to help determine the results of the color analysis.

Color Measurement Settings: Fixed Luminance

The user can fix the luminance of the displayed color. Since antireflective coatings, for example, are inherently transmitting, the spectra has very little luminance and the coating color may appear black on screen. Fixing the luminance does not affect the color space coordinate results.



Spectrum colors of the same spectrum with fixed luminance of 10%, 40%, and 70%, respectively. Note that fixing the luminance to view the color does not affect the color space coordinate values.

Number of Spectra

This sets the maximum number of spectra displayed simultaneously on the main FILMeasure screen. If the maximum number of spectra is reduced to fewer than the number already on the screen, the most recently selected spectra will remain.

Spectra Transformation

On spectra where reflectance and transmittance information is present you can have the software display them as separate spectra (none), added together (sum), or the absorptance (1-R-T).

Graph Options

The background of the graph can be set to white or black using this option, as well as allowing the software to auto-position the legend box to avoid or minimize overlap with the displayed spectra.

Measurement Results: Significant Digits

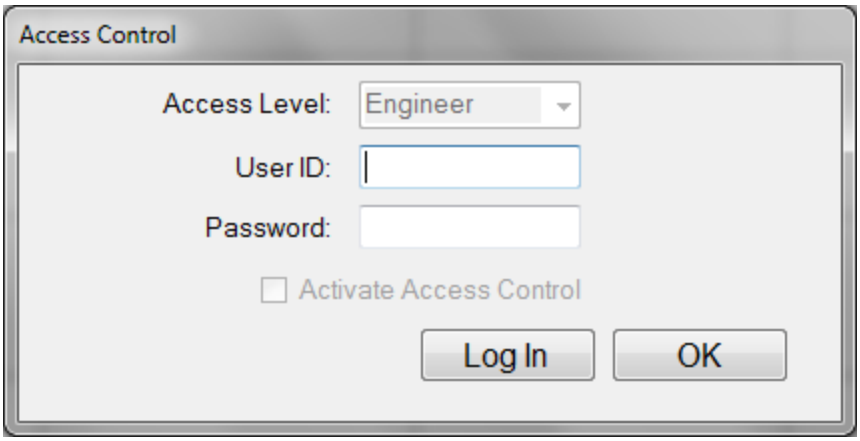
The user can select the number of significant figures, from 1 to 7, that the results are displayed in. For example with the units set to Angstroms, if a result of 7213 Å will be displayed for 4 significant digits, it will be displayed as 7210 Å for 3 significant digits.

Displayed Controls

These checkboxes are used to determine which controls are listed on the right hand side of the FILMeasure window.

Access Control

The software for the instrument incorporates password protection to limit access to the measurement software and settings. When the software is initially installed the access control is turned off. The software will automatically boot up with Engineer level access that enables access to all features of the program except turning on and off access control and adding and deleting users.



Turning on access control requires Supervisor level access. The software is delivered with one user, a supervisor, in the list of authorized users as shown below:

UserID: filmsuper

Password: filmetricsfff

To turn on access control, log in as filmsuper using the password shown above. The **Activate Access Control** checkbox should now be enabled. By placing a check mark in the **Activate Access Control** checkbox access control will be active. User ID and Password are case-sensitive.

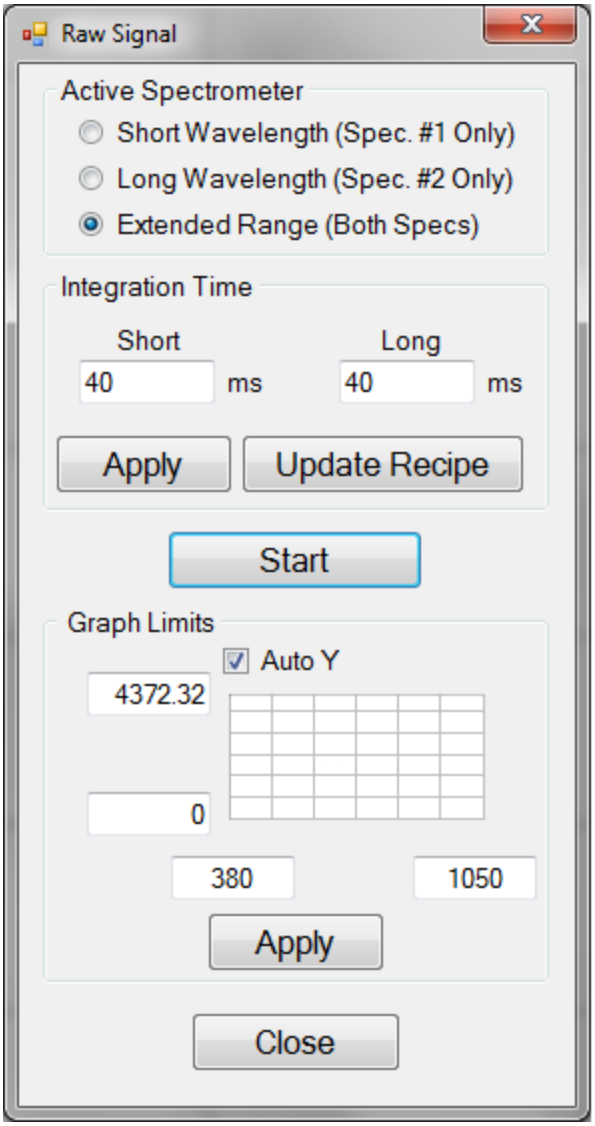
To add an operator level user, select operator from the **Access Level** list box, type a user name and type an initial password for that user. Then click the **Add User** button. To add an engineer or a supervisor user follow the same procedure, but pick the appropriate access level from the list box before pressing the **Add User** button.

To delete a user, enter the **UserID** and press the **Delete User** button.

Operator and Engineer level users can change their passwords when they are logged in by entering their password into the password box and pressing the change button. Supervisor-level users can change their password or the password of any other user by selecting the appropriate access level, entering the appropriate **UserID** and the new password and pressing **Add User**. If the program finds that a user already exists, it will delete the old entry for that user and create a new entry.

We recommend that you create a new supervisor level user and delete the filmsuper user for maximum security. If all supervisor level users forget their passwords, it will be necessary to re-install the software and add all the users again.

Raw Signal



Raw Signal

The **Raw Signal** dialog box allows the user to plot the raw (no baseline corrections applied) spectrometer signal on the main graph. No spectral smoothing is applied, and there are no saturation warnings. This is useful when setting integration times manually.

Active Spectrometer

For systems with multiple spectrometers (EXR and UVX) these radio buttons allow you to select between collecting data from the short wavelength, long wavelength, or both spectrometers.

Integration Time

This sets the integration time of the spectrometer. Clicking **Update Recipe** transfers the listed integration time to the current recipe.

Start/Stop

This button starts/stops the acquisition of the spectrometer signal.

Graph Limits

This allows the user to either manually set or autoscale the graph limits.

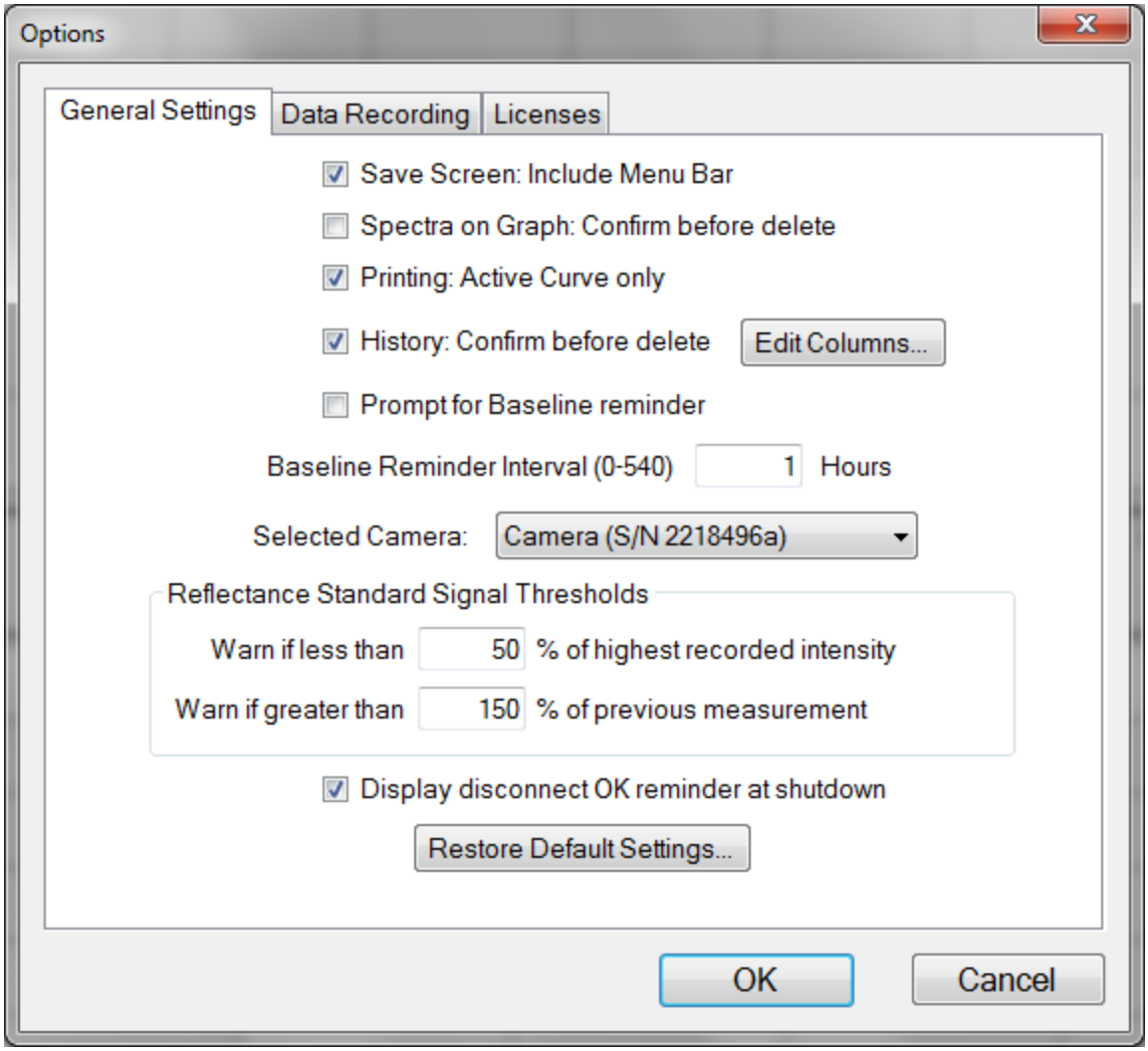
Options

The **Options** menu allows the user to enable, disable, or modify several different settings within FILMeasure. Users can also view which licenses are currently active on their system, and enable or disable them under the **Licenses** tab.

[General Settings]

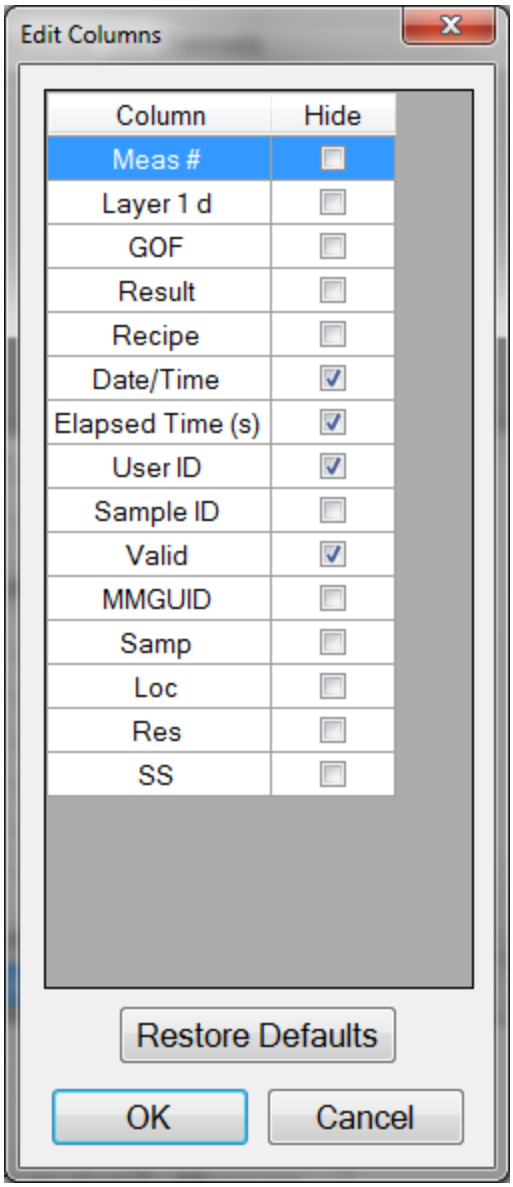
[Data Recording]

General Settings

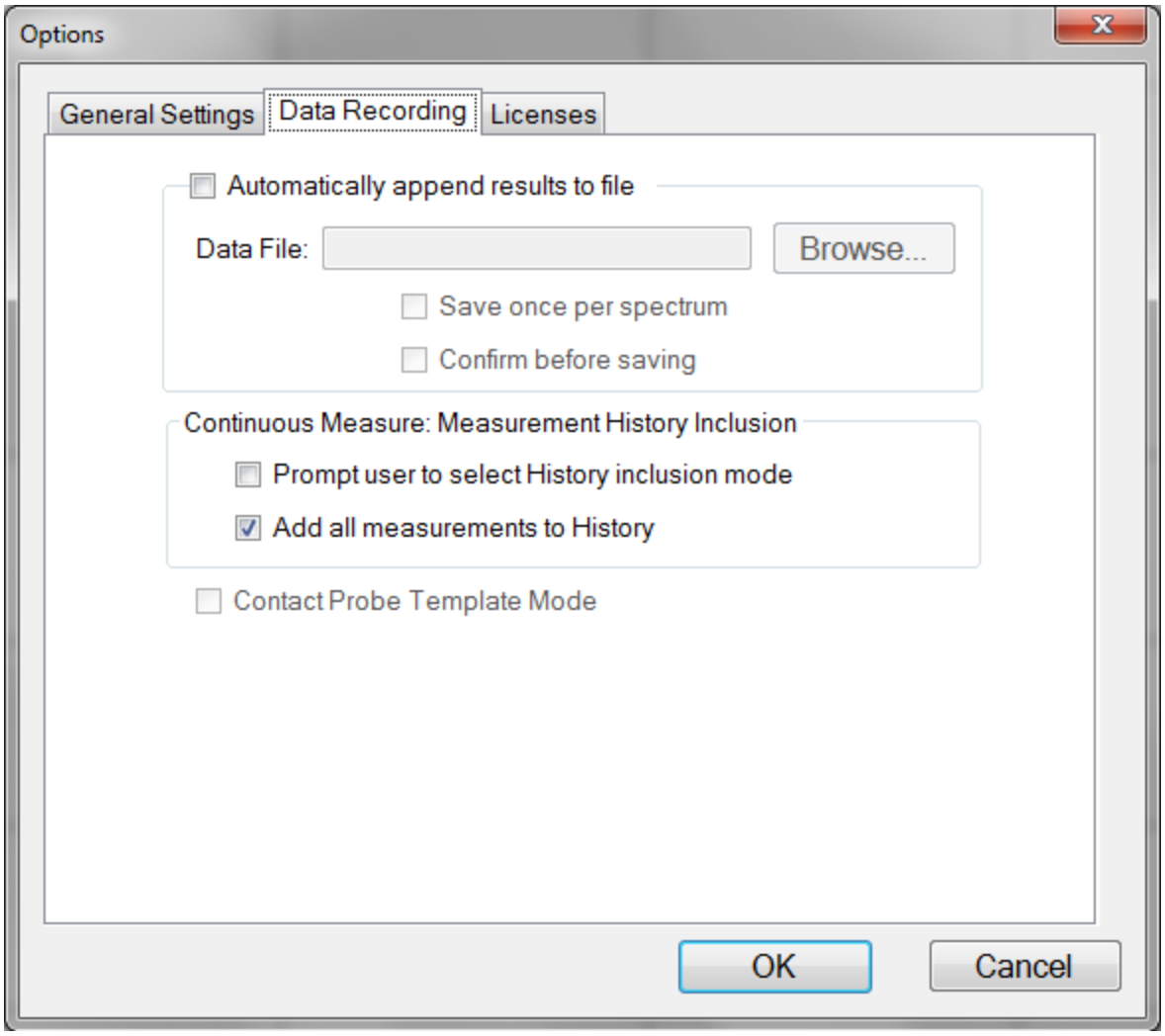


The **General Settings** tab is used to enable, disable, and modify various options in the software. **Baseline Reminder** allows the user to set an interval at which the system will alert them to re-baseline the system. It is set at one hour by default. The **Selected Camera** pull down menu allows the user to enable the **Sample Cam**, or choose between different cameras if there is more than one attached to the system. The **Reference Signal Thresholds** options are used by the software during the **Baseline** process. If, during the **Acquire Reference** step of the **Baseline**, the intensity of the reflectance standard goes above or below the percentages listed an error message will appear.

The **Edit Columns** button open a dialog box that allows the user to select which columns are shown in the history tab. This dialog box can also be accessed by right clicking anywhere in the spectrum list under the history tab. Click on **Restore Defaults** to remove all selections.

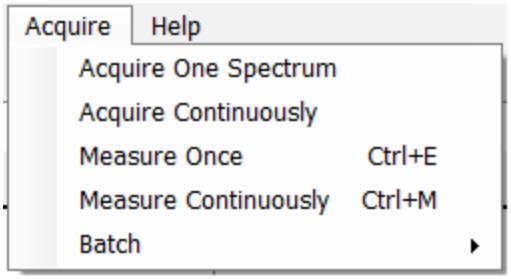


Data Recording



The **Data Recording** tab allows for automatic saving of all spectra and results to a central file. The user can also select between having the software provide a prompt for which data to include in the history file when using **Acquire>Continuous Measure** or to include all measurements to history.

Acquire Menu



Acquire > Acquire One Spectrum

This function collects a single spectrum and displays it on the screen. No analysis is performed until the recipe is changed or the **Analyze** button is clicked.

Acquire > Acquire Continuously
This feature collects real-time data from the spectrometer. It is useful when searching for a specific location to measure (for example, locating a more uniform area of the sample, or one that exhibits interference fringes).

Acquire > Measure Once
This feature collects a spectrum, analyzes it and displays it on the screen. This is the same as pressing the **Measure** Button. For systems with the **Sample Cam**, this saves an image to the spectrum file created.

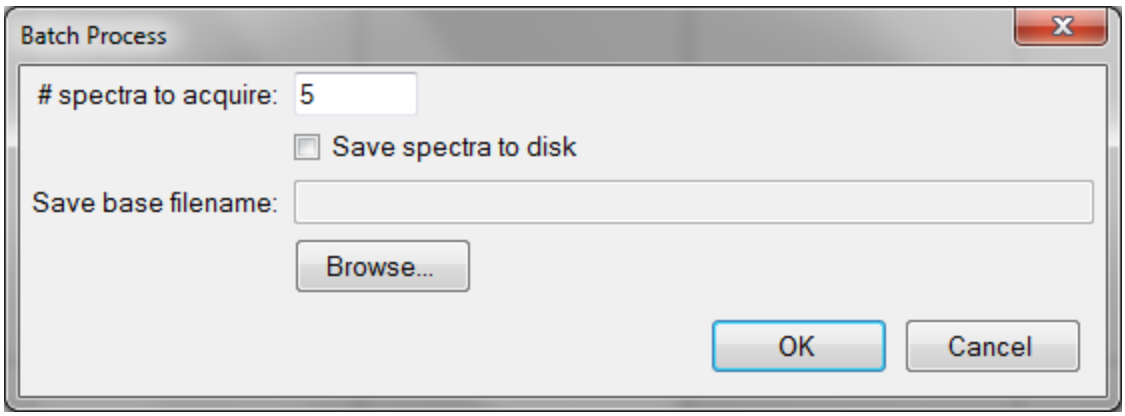
Acquire > Measure Continuously
This feature collects real-time spectrum data and analyzes it – similar to repeatedly pressing the Measure button. A measurement interval time can be set in the recipe using the **Advanced** options underneath the **Acquisition Settings** tab.

Batch Acquire

The Batch functions allow you to act on groups of spectra, rather than each individual spectrum

Acquire > Batch > Acquire

This option allows you to acquire a pre-selected number of spectra. You can also choose to save the batched spectra as they are acquired.



Acquire > Batch > Measure

This option allows you to acquire and analyze a pre-selected number of spectra. You can also choose to save the batched spectra as they are acquired.

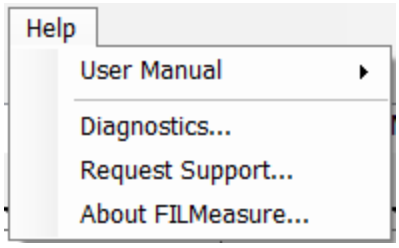
Acquire > Batch > Analyze Spectra

This option allows the user to select multiple spectra for analysis by the current recipe. If there are more spectra to be analyzed than the software is set to **Display**, the analyzed spectra can easily be retrieved from the **History** tab.

Acquire > Batch > Analyze All Spectra in Folder

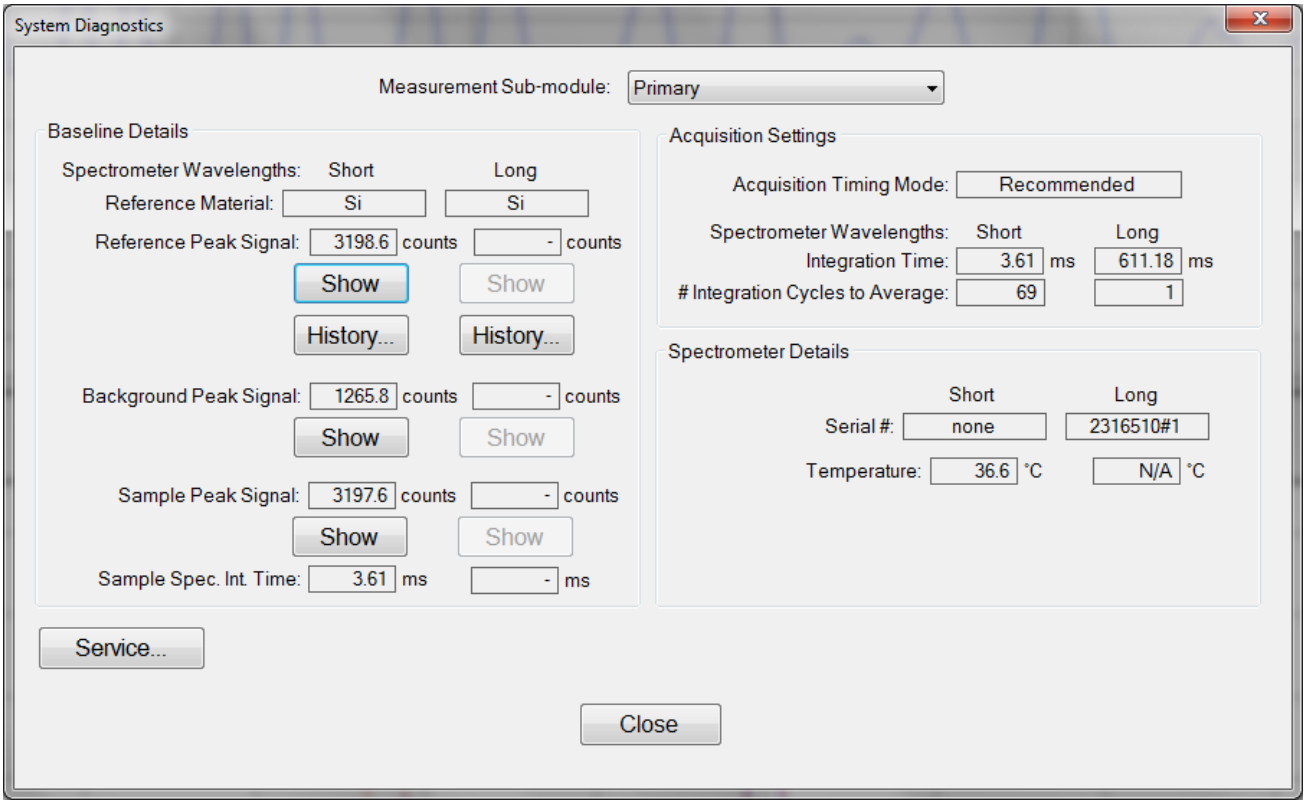
This option will analyze every spectrum in a folder with the currently selected recipe. If there are more spectra to be analyzed than the software is set to **Display**, the analyzed spectra can easily be retrieved from the **History** tab.

Help Menu



Diagnostics

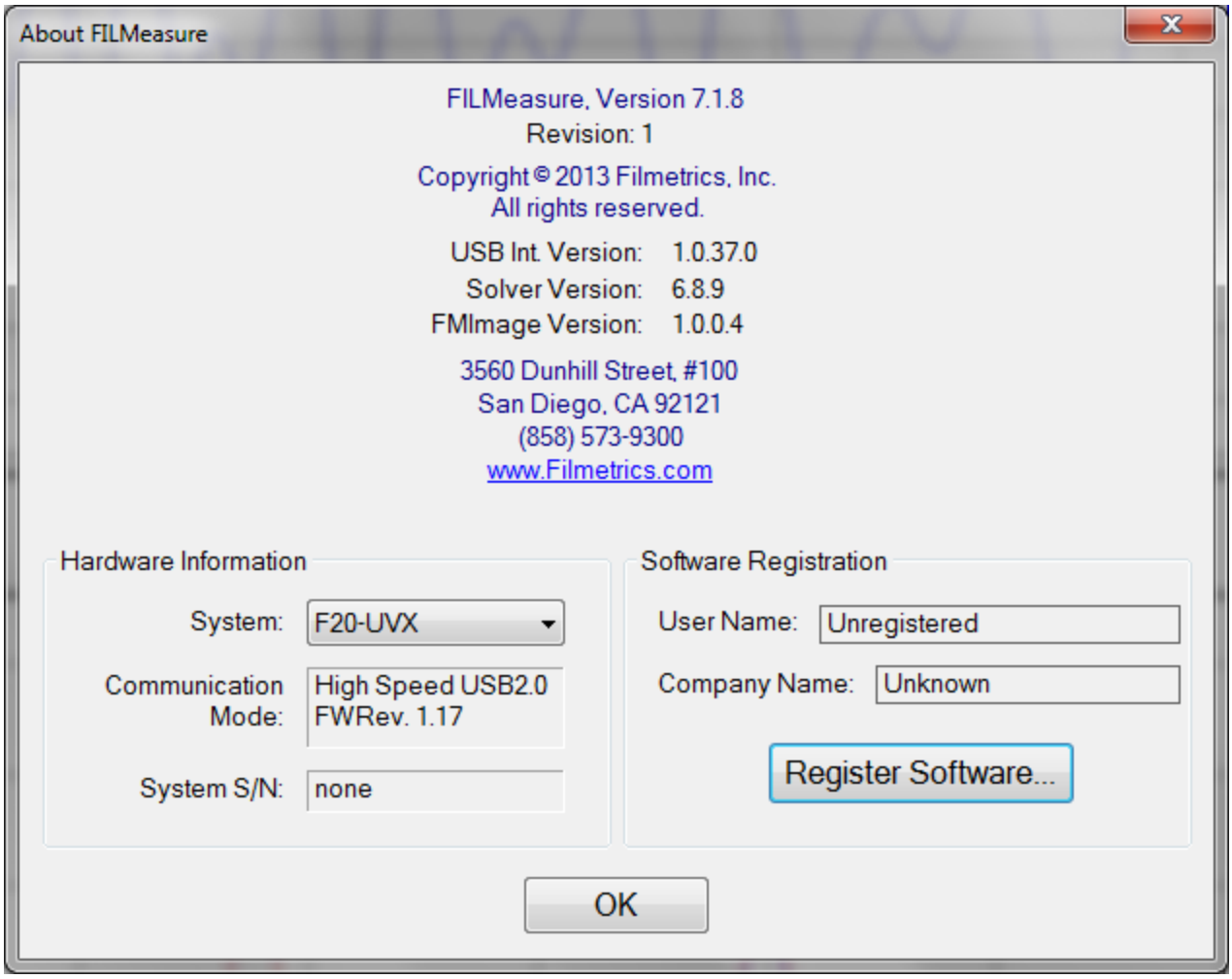
The diagnostics window gives information regarding the data taken during the baseline. Reference and background counts are shown (this is useful to see how much signal the system is getting; good signals typically are between 2500-3500 counts).



Help>Diagnostics shows the user information regarding the data taken during the baseline routine.

Help > About FILMeasure

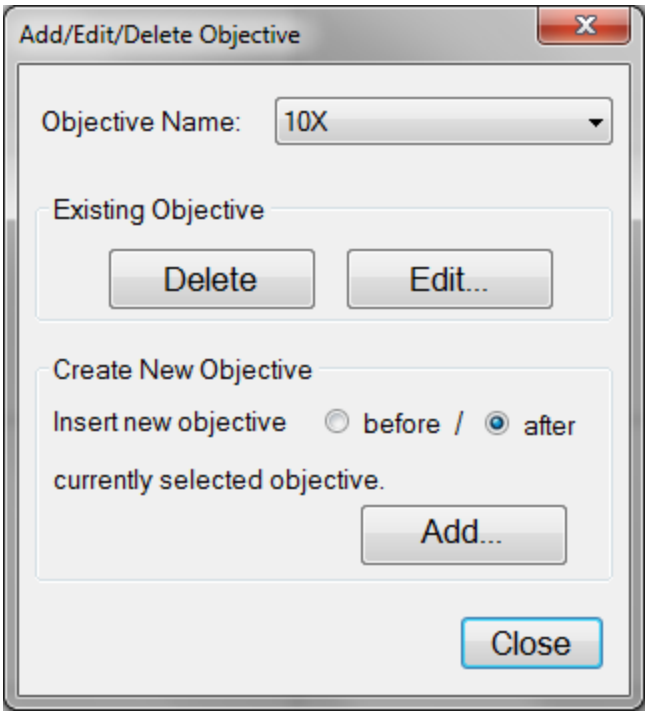
Information about the hardware and software versions and the system serial number can be found here. Please have this information available when calling Filmetrics for technical assistance.



Help>About FILMeasure... window

Calibrating the Objective

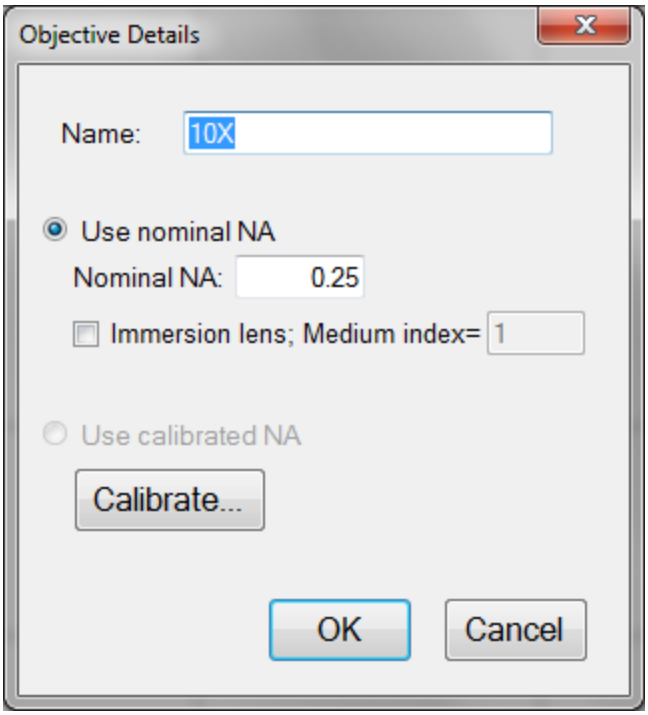
Since optics vary from microscope to microscope, the objective lenses must be calibrated for optimal measurement performance. For each objective lens that does not already have a calibration file, select **Add/Edit/Delete** from the **Objective Name:** pull-down menu on the main screen of FILMeasure.



The **Add/Edit/Delete Objective** Menu Box.

Here, the user can delete or edit/recalibrate the selected objective, or add a new one. Selecting **Add** will prompt the user to name the objective and to enter a nominal numerical aperture (NA) in the **Nominal NA:** box. The NA of the objective can be found printed on the microscope objective. Once entered, selecting **Calibrate…** will guide the user through the calibration process. From here, the user should follow the on-screen instructions.

If the user prefers to not go through the calibration routine, the user can also enter the nominal NA in the **Nominal NA:** box, select **Use Nominal NA**, and press **OK**. Choosing this method, however, will yield thickness values with a greater percent error than calibrating the objective through software.



The **Objective Details** dialog box.

Taking a Baseline

The baseline measurement allows the FILMeasure software to take into account the response inherent to the reflectance measurement hardware. It does this by first measuring the sample reflectance, then a reflectance standard, and finally by taking a "dark" reading. The light source should be allowed to stabilize at least five minutes before the baseline is taken. When measuring films less than 1000 Å thick, the baseline should be periodically re-taken every 20-30 minutes. For thicker films, a new baseline can be taken less often.

Baseline measurements may be started two ways:

1. Select the **Baseline** button, which will guide the user through the baseline procedure, or

2. Select **Set Up>Standard/Background...** from the menu bar for manual access to the baseline functions.

The following instructions assume the user has already focused the system and clicked the **Baseline** button. For instructions on focusing on featureless surfaces, see Focusing on a Perfectly Flat Surface.

The first step of the baseline measurement is to acquire a spectrum of the sample. This is done by placing the sample on the stage underneath the light path. This step is used by the software to help determine the needed integration times and cycles to best measure the sample.

The next step is to take a spectrum of a reflectance standard. This done by placing a reflectance standard of similar reflectance to the test sample on the sample stage. The reflectance standard that is used should be selected from the **Reflectance Standard**: list. For reflectance standards not in the list,

reflectance versus wavelength values may be entered into a comma-delimited text file with the extension ".rrr" (stored in the material subfolder).

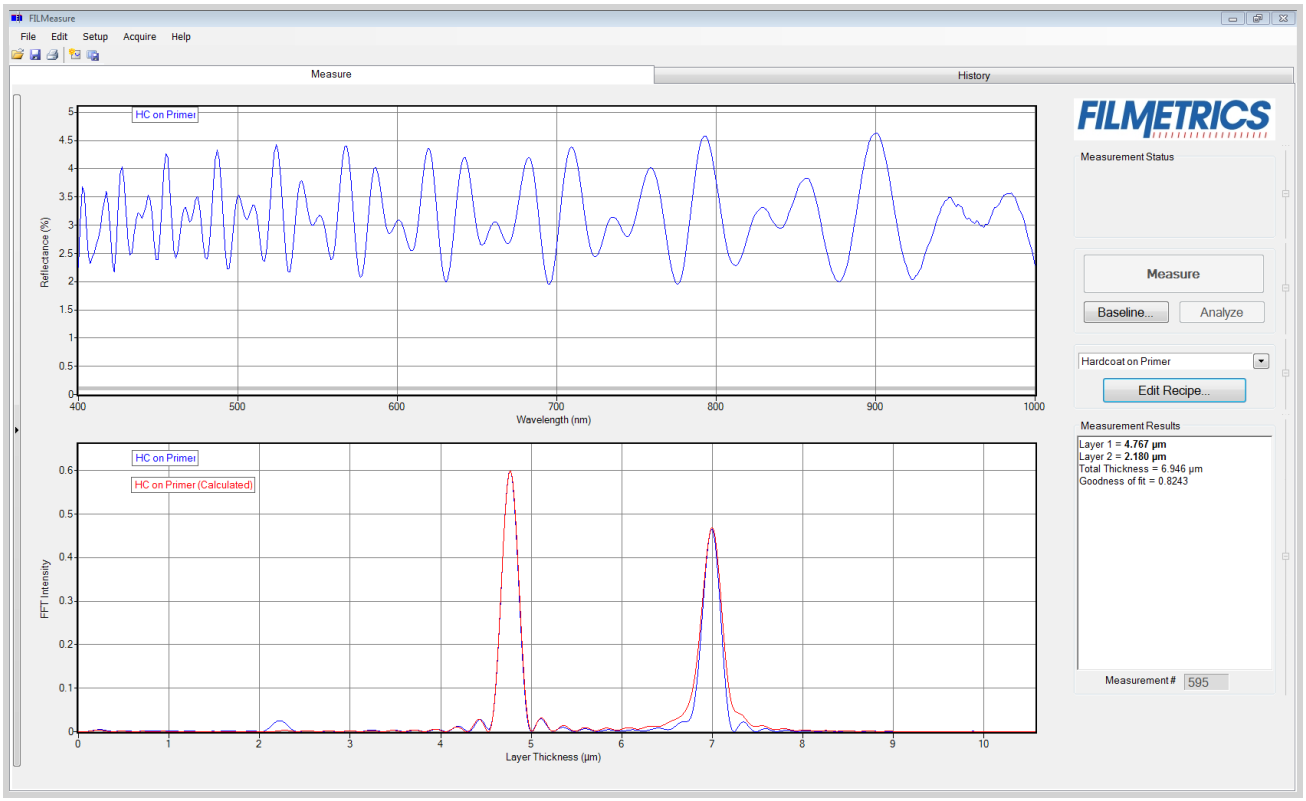
The method the background measurement is taken is dependent on the optical set-up.

After acquiring a baseline, the instrument is ready to begin making measurements. To verify that the system is working properly, select **Acquire One Spectrum** from the **Acquire** menu with the reflectance standard in place. You should see the reflectance spectrum of the reflectance standard.

Fast Fourier Transform Mode (FFT mode)

The FFT mode tends to be more robust when measuring very thick films or thick multi-layer stacks, where the total thickness is greater than 5 microns.

To activate FFT mode, select the select **FFT (thickness only)** button located on the **Analysis Options > Analysis Method** tab in the **Edit Recipe** box.



The **Measure Tab** shows a split screen with the measured spectrum on the top graph and the FFT spectrum on the bottom graph.

In FFT mode, instead of matching the measured reflectance spectrum with a calculated reflectance spectrum, FILMeasure identifies the peaks in the FFT Spectrum and uses them to compute the layer thicknesses. The number of possible FFT peaks is n*(n+1)/2 where n is the number of layers. Thus, for a two layer structure, we expect to see three peaks in the FFT spectrum.

The image above shows the screen just after measurement of a two layer stack using FFT mode. The upper graph shows a blue curve representing the reflectance spectrum of the sample. The lower graph shows a blue and red FFT spectrum. The blue FFT spectrum is computed from the measured reflectance. The red FFT spectrum is computed from the theoretical reflectance spectrum of a layer stack with the measured layer thicknesses. The small side lobes visible on either side of the two tall peaks are artifacts of the FFT process and can generally be ignored. The only time the side lobes will cause a problem is if a weak peak from a multi-layer sample is very close to a much stronger peak. If this case occurs FILMeasure may lock onto one of the side lobes by mistake and it may not be possible to measure the layer thickness associated with the weak peak. Reducing the **Constraint** and/or increasing the guess for the thickness for the layer with the weak peak may be helpful in getting FILMeasure to lock onto the weak peak. If the peak is too weak to reliably measure it is best to change the layer structure definition so that the layer corresponding to the weak peak is eliminated.

Along with the measured layer thicknesses, the **Results** text box displays important information about the measurement. This important information includes the **Goodness Of Fit (GOF)** and a description of which peaks were used to determine the measured layer thicknesses. In the figure above layer 1 thickness is determined based on the position of the peak located at 4.780 microns and layer 2 thickness is determined using the peak corresponding to layers 1+2 (7.011 microns). Notice that the thickness of layer 2 is not exactly equal to 7.011-4.780 = 2.231 microns. FILMeasure computes a thickness for layer 2 of 2.113 microns because it precisely accounts for the fact that layer 2 has a different refractive index than layer 1.

Discussion of GOF:

A perfect match between measured and theoretical FFT spectra will result in a **GOF** of 1. To ensure accurate results the user may set a minimum acceptable **GOF** value by entering a number between 0 and 1 into **GOF Error** on the **Alarms** settings in **Edit Recipe**. A warning message will be displayed after each measurement where the **GOF** falls below the user-specified **GOF Error**. If the **GOF** is less than 1 there are several possible causes as follows:

a) Nonuniformity – Any variation of layer thickness within the measurement spot will result in a reduction in the FFT peak heights. In order to permit easy visual interpretation of the FFT results FILMeasure always scales the amplitude of the red curve so that it matches the blue curve. However, if the scaling factor is not 1.0, FILMeasure reports a reduced GOF even if the red curve appears to exactly match the blue curve on the screen.

b) Incorrect Structure Definition – If the refractive index of one or more layers in the structure is different from what is described in the layer structure, then the FFT peak amplitudes in the blue curve will not match the peak heights in the red curve. The software will attempt to scale the red curve, but if there is more than one FFT peak present, the scaling will only result in one correct peak height. If you wish to view the impact of changing the refractive index of one or more layers, simply change the refractive index in the **Edit Recipe** dialog box and click **Analyze (ReAnalyze)**. If there is only a single layer you will notice that the GOF will change, but the red curve should not change much. If there are multiple layers in the structure you will notice that the relative peak heights in the red curve will change when you click **Analyze**.

c) Graded Interfaces – The amplitude of the peaks in the FFT spectrum depends on both the difference in refractive index at each interface in the layer structure and the sharpness of the interface. In many common samples you will find that there is some degree of layer intermixing at the interface, leading to a weaker than expected reflectance at that interface. The FFT peak(s) associated with the intermixed interface will suffer a reduced amplitude and in severe cases the peaks may disappear entirely.

Making Measurements

Accurate measurements with the F40 rely on using the proper measurement setup. The basic steps for any F40 measurement are:

1) Selecting and editing the type of film to be measured
2) Taking a **Baseline** measurement
3) Clicking on the **Measure** button to acquire and analyze the measured spectrum.

Each example below will take you through this sequence of steps. In each example it is assumed that the hardware has been set up as described in the **Quick Start Guide**, and that you have first read through the **Software Overview** section to familiarize yourself with the basic controls.

The **Measurement Assumptions**, **Hints for Improved Accuracy**, and **Troubleshooting** sections describe techniques that should be followed for the most accurate measurements.

Focusing a Microscope Image on a Perfectly Flat Surface

In many cases samples will have visible features that allow users to focus a microscope image. However, for perfectly specular (mirror-like) samples focusing the microscope may be difficult. In these cases, the **Köhler illumination** technique, which almost all reflected light microscopes use, can be helpful in obtaining a focused image despite a lack of visual reference points on the sample. In a Köhler illuminated microscope there are three additional focal points in the light path. One in particular, the field diaphragm, can be used to focus the microscope.

Focusing the image using the field diaphragm (field stop)

To focus using the field diaphragm (also called field stop and abbreviated F.S.) follow the steps listed below:

1. Start with a sample that has visible features that allow you to focus by eye (the Filmetrics Focus/Reference Wafer works well if you have one).

2. Turn on the microscope's light source and open both the field diaphragm and aperture diaphragm. These two diaphragms are located between the light source and the microscope column.

3. Focus the image by adjusting the distance from the sample to the objective.

4. Once you have obtained a focused image, slowly close the field diaphragm (the one furthest away from the light source) until it becomes visible in the image. This diaphragm should be in focus simultaneously with the sample image.

5. (Optional) Adjust the position of the field diaphragm using the two adjustment screws so that the diaphragm is centered in the image.

6. Open the diaphragm but leave the edge in view. Now you can move to a perfectly specular sample location, say a Si wafer, and focus on the field diaphragm knowing that when the field diaphragm is in

focus, so is the Si wafer sample. When focused, you can open up the diaphragm out of the field of view to collect maximum light.

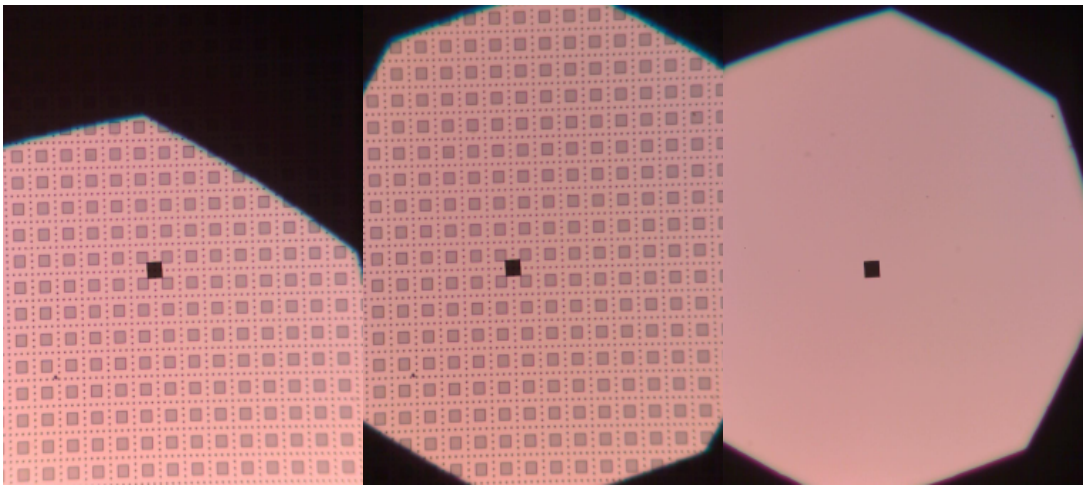


Figure 1: From left to right: Closing the field diaphragm on a focused image, centering the field diaphragm using adjustment screws, and focusing on a Si wafer using the field diaphragm as a reference point.

Measuring Thickness

Examples that describe the most common measurement setups are described in this section.

Example 1: Measuring Single Layer Films.

Example 2: Measuring Multi-Layer Films.

Example 3: Measuring Films on Transparent Substrates.

Example #1: Measuring Single Layer Films

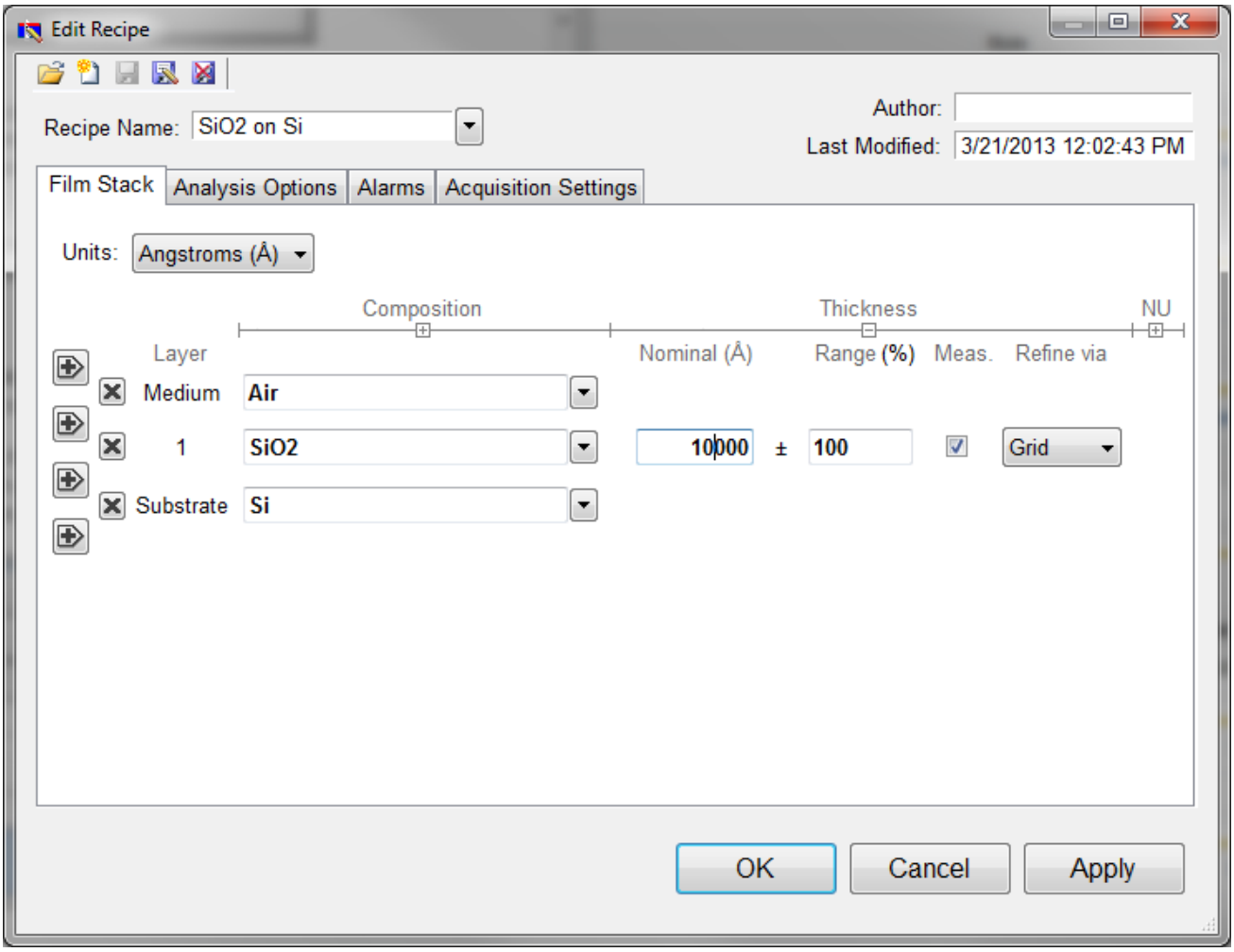
In this example we will demonstrate the measurement of SiO2 on Silicon using the TS-Focus-SiO2-4-10000 thickness standard provided with the system. This type of measurement applies to an extremely broad range of applications, including hardcoats, dielectrics, and LCD cell gaps to name just a few.

Step 1: Select the Film Recipe

Select the film structure to be measured, in this case "SiO2 on Si", from the **Recipe** drop-down list on the main screen. If the structure to be measured does not exist, a new structure must be defined. See **Editing Film Recipes** for more details.

Step 2: Edit the Film Recipe

To edit the film stack, click the **Edit Recipe...** button to open the dialog box. Check to see that the film stack matches that of the actual sample. If not, different films can be selected using either the drop down menu next to the material or the **Search** function. This is also where you can enter a starting guess for thickness as well as the desired constraint range.



Example Edit Recipe>Film Stack window

For this example, we'll use 10000 angstroms ( ) as the **Nominal** thickness, with a constraint range of 100%. Make sure that the SiO2 layer thickness is being solved for by clicking the checkbox under **Meas**. The substrate should be set to Si. Under the **Analysis Options** tab, set the **Analysis Method** to **Exact**, with nothing else enabled. Once the changes have been made, the recipe can be saved by clicking on the save icon , or confirm the changes without saving over the recipe by clicking the **OK** button.

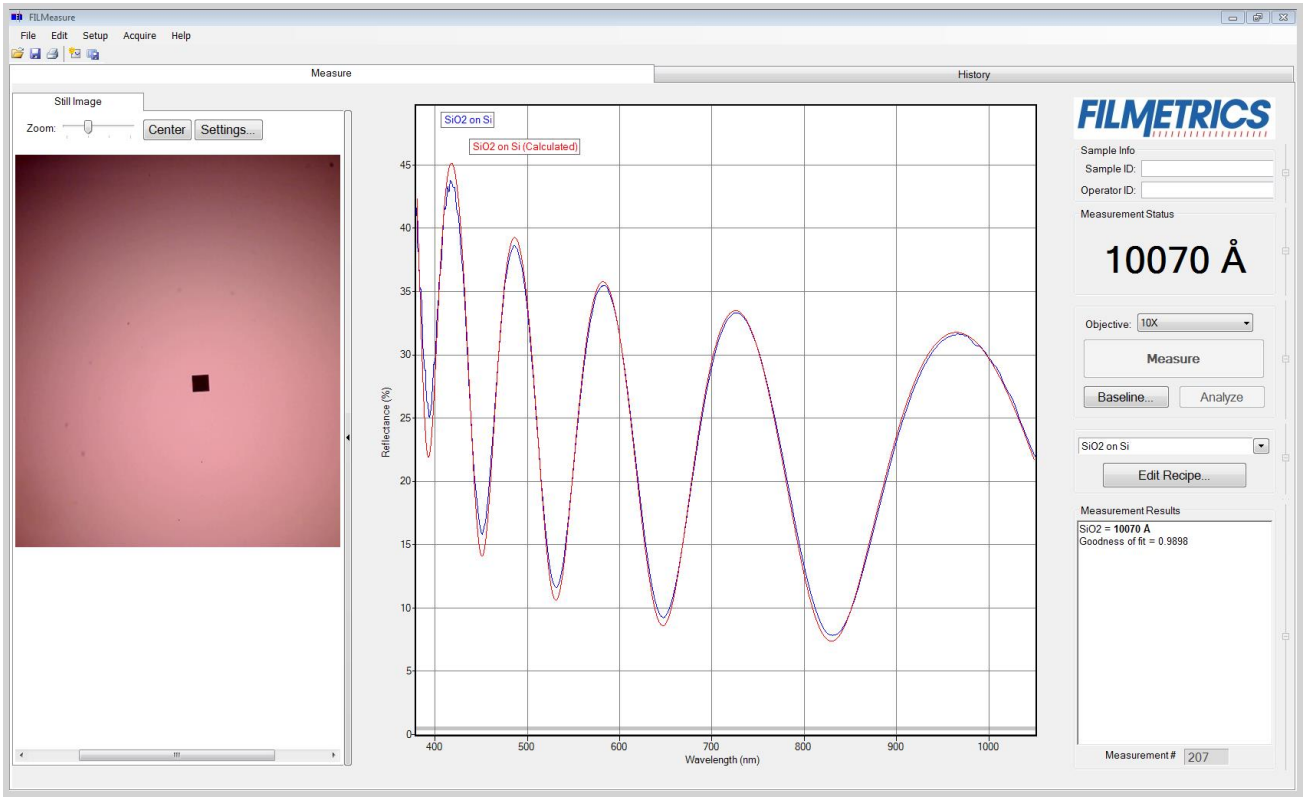
Step 3: Take a Baseline Measurement

Take a baseline measurement by first clicking on the **Baseline** button on the main screen. A dialog box will appear to guide you through the process. Follow the steps on screen, and be sure to match the material selected with the reflectance standard that will be used. If you're finding it difficult to focus the system, see **Focusing a Microscope Image on a Perfectly Flat Surface** for help. For this example use the reference square on the TS-Focus-SiO2-4-10000 as your Si reflectance standard.

Step 4: Make the Measurement

Make the measurement by placing the TS-Focus-SiO2-4-10000 on the stage with the SiO2 square underneath the light path, and then click on the **Measure** button.

FILMeasure will then acquire the reflectance spectrum and calculate the corresponding thickness. If the measurement was successful, the minima and the maxima of the calculated reflectance (the red line on the graph) will coincide in wavelength with the minima and the maxima of the measured reflectance (the blue line on the graph). In most cases they will not overlap, but will be separated in amplitude.



Measured and calculated reflectance spectra when measuring the thickness of SiO2 on silicon.

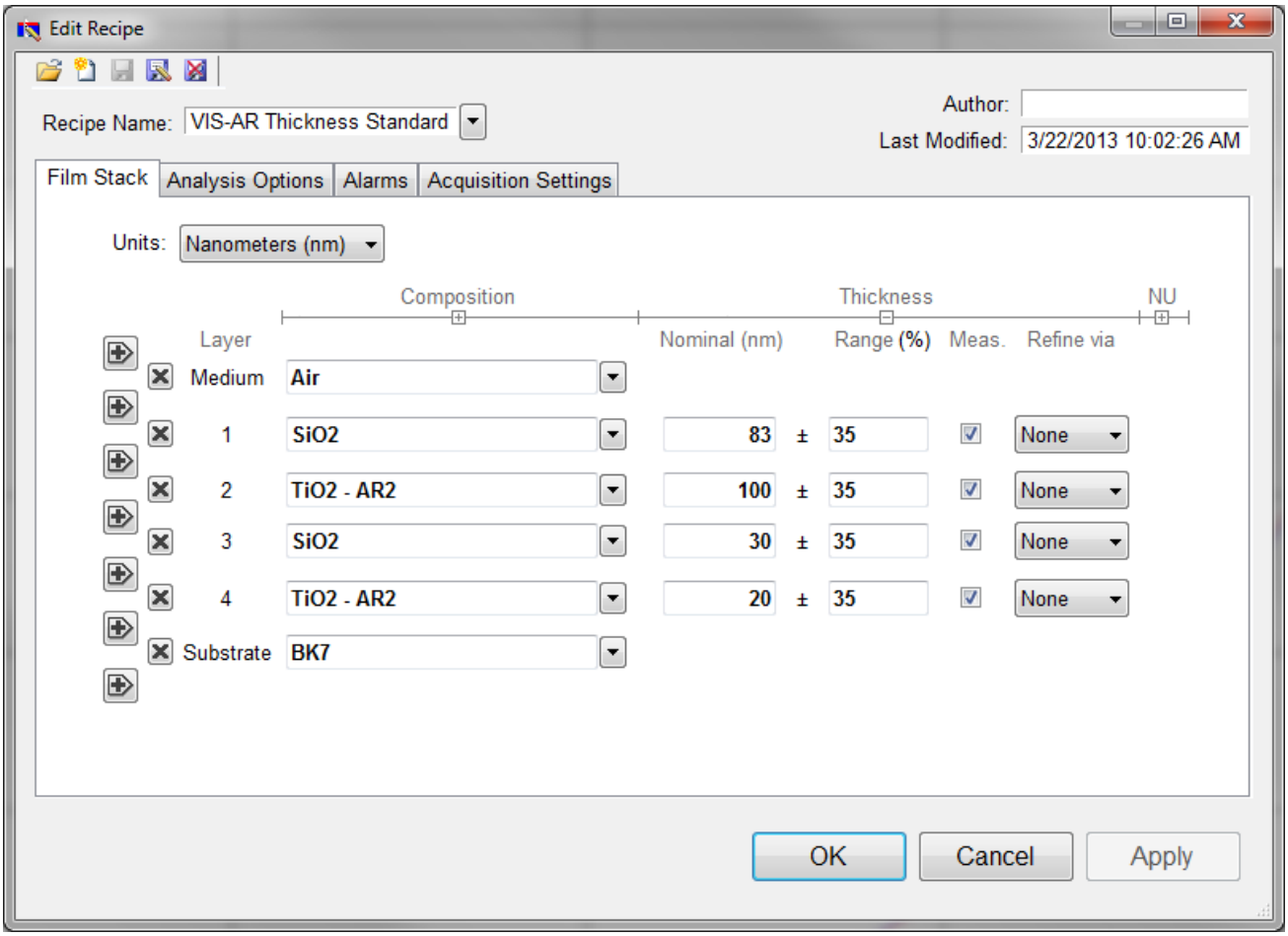
If the calculated (red) and measured (blue) minima and maxima do not coincide, then the measurement was not successful. There are several possible causes of an unsuccessful measurement. The most common for this type of measurement are described in **Cases #1**, **#2**, and **#3** in the **Troubleshooting** section.

Example #2: Measuring Multi-Layer Films

This example demonstrates the measurement of multi-layer films using the VIS-AR reflectance standard. This type of measurement has a broad range of other applications, most commonly optical coatings, SOI wafers, and flat-panel display process films.

Step 1: Select the Film Recipe

Select the film structure to be measured, in this case “VIS-AR Thickness Standard”, from the **Recipe:** list box on the main screen. If the structure to be measured does not exist, a new structure must be defined. See **Editing Film Recipes** for more details.



Example Edit recipe>Film Stack window for measuring the VIS-AR Reflectance Standard.

Step 2: Edit the film recipe

To edit the film stack, click the **Edit Recipe...** button to open the dialog box. Check to see that the film stack matches that of the actual sample. If not, different films can be selected using either the drop-down menu next to the material or the **Search** function. If there are fewer layers present in the recipe than there are in the film stack of your sample, additional layers can be added with the [+] buttons on the left hand side. The [X] buttons can be used to remove additional layers if there are too many present. This is also where you can enter a starting guess for thickness as well as the desired constraint range.

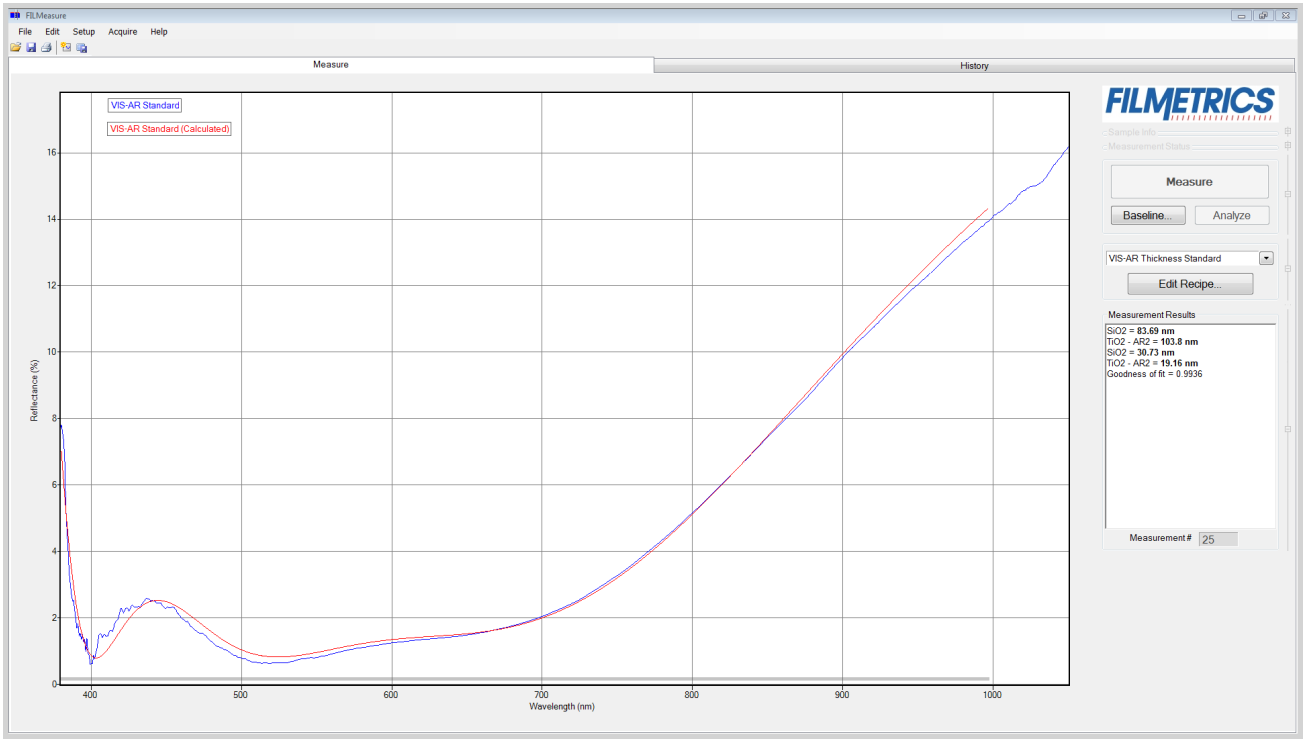
For this example, we'll use 83 nm as the **Nominal** thickness for the first layer, 100 nm for the second, 30 nm for the third and 20 nm for the fourth. When solving for multiple layers, it is suggested to use smaller constraints ,35% in this case, to help improve solver speed and accuracy. Make sure that the layer thicknesses are being solved for by clicking the checkboxes under **Meas**. The substrate should be set to BK7. Underneath the **Analysis Options** tab, set the **Analysis Method** to **Exact**, with nothing else enabled. Once the changes have been made, the recipe can be saved by clicking on the save icon , or confirm the changes without saving over the recipe by clicking the **OK** button.

Step 3: Take a Baseline Measurement

Take a baseline measurement by first clicking on the **Baseline** button on the main screen. A dialog box will appear to guide you through the process. Follow the steps on screen, and be sure to match the material selected with the reflectance standard that will be used. For this example use the BK7 reflectance standard. If you are having trouble focusing, and your microscope has a field stop, you can use **this guide** to help focus your system. Otherwise, the edge of the BK7 or any surface scratches can be used to help focus the system.

Step 4: Make the Measurement

Make the measurement by placing your sample on the stage and then click on the **Measure** button. FILMeasure will then acquire the reflectance spectrum and calculate the corresponding thickness. If the measurement was successful, the minima and the maxima of the calculated reflectance (the red line on the graph) will coincide in wavelength with the minima and the maxima of the measured reflectance (the blue line on the graph). In most cases they will not overlap, but will be separated in amplitude.



Measured and calculated reflectance spectra when measuring the thickness of the VIS-AR Reflectance Standard.

If the calculated (red) and measured (blue) minima and maxima do not coincide, then the measurement was not successful. There are several possible causes of an unsuccessful measurement. The most common for this type of measurement are described in **Cases #1** and **#2** in the **Troubleshooting** section.

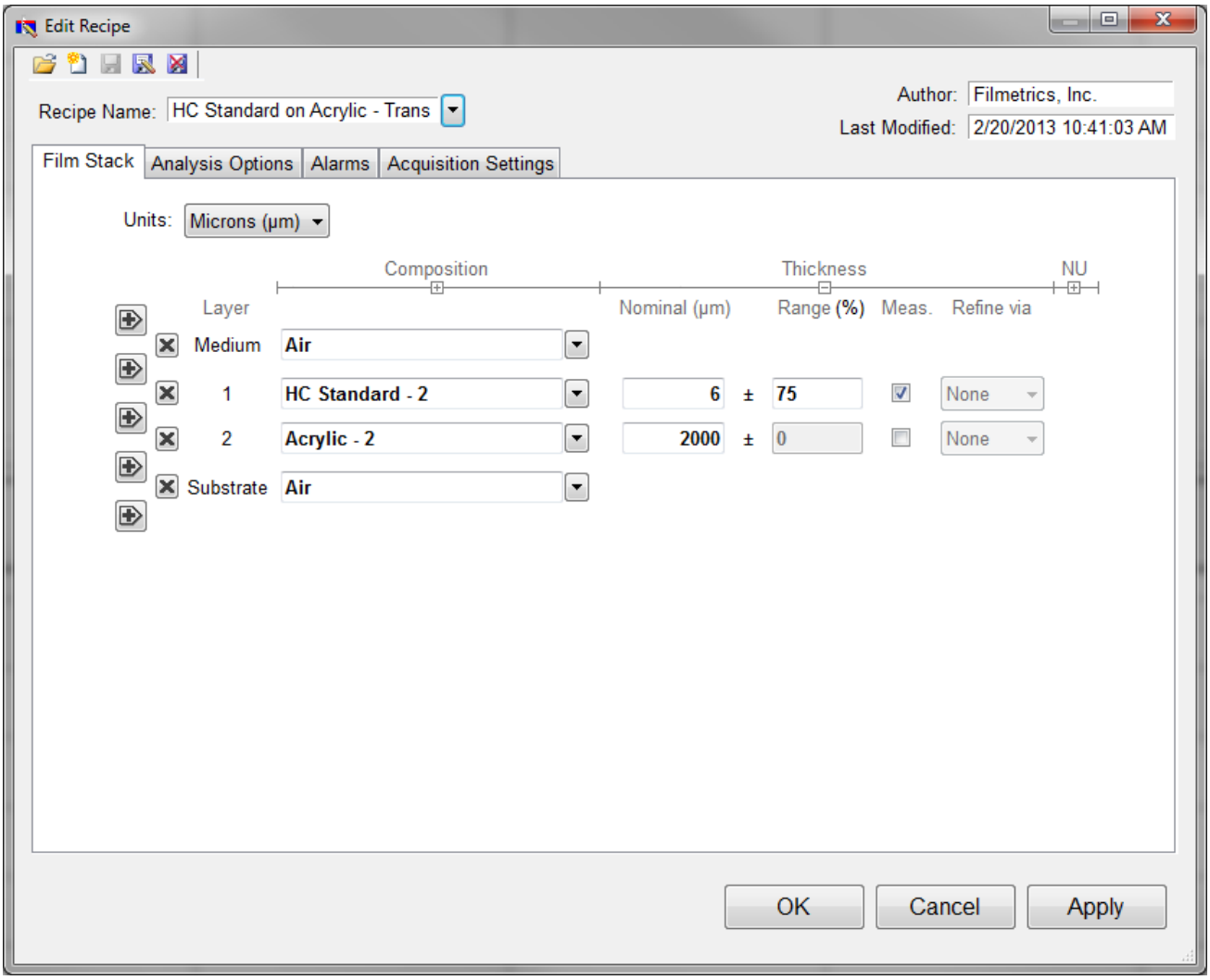
Example 3: Measuring Films on Transparent Substrates

In this example, we will demonstrate the measurement of a hardcoat on acrylic using the TS-Hardcoat-Trans thickness standard. This type of measurement applies to a broad range of applications, including packaging films, and coatings on glass or polymeric substrates.

Step 1: Select the film recipe

Select the film structure to be measured, in this case “HC Standard on Acrylic - Trans”, from the **Recipe**: list box on the main screen. If the structure to be measured does not exist, a new structure must be defined. See **Editing Film Recipes** for more information.

Step 2: Edit the film recipe



Example **Edit Recipe>Film Stack** window for measuring the thickness of a film on a transparent substrate

To edit the film stack, click the **Edit Recipe...** button to open the dialog box. Check to see that the film stack matches that of the actual sample. If not, different films can be selected using either the drop-down menu next to the material or the **Search** function. This is also where you can enter a starting guess for thickness as well as the desired constraint range.

For this example, set the **Nominal** thickness at 6 microns, with a constraint range of 75%. Make sure that the HC Standard - 2 layer thickness is being solved for by clicking the checkbox under **Meas**.

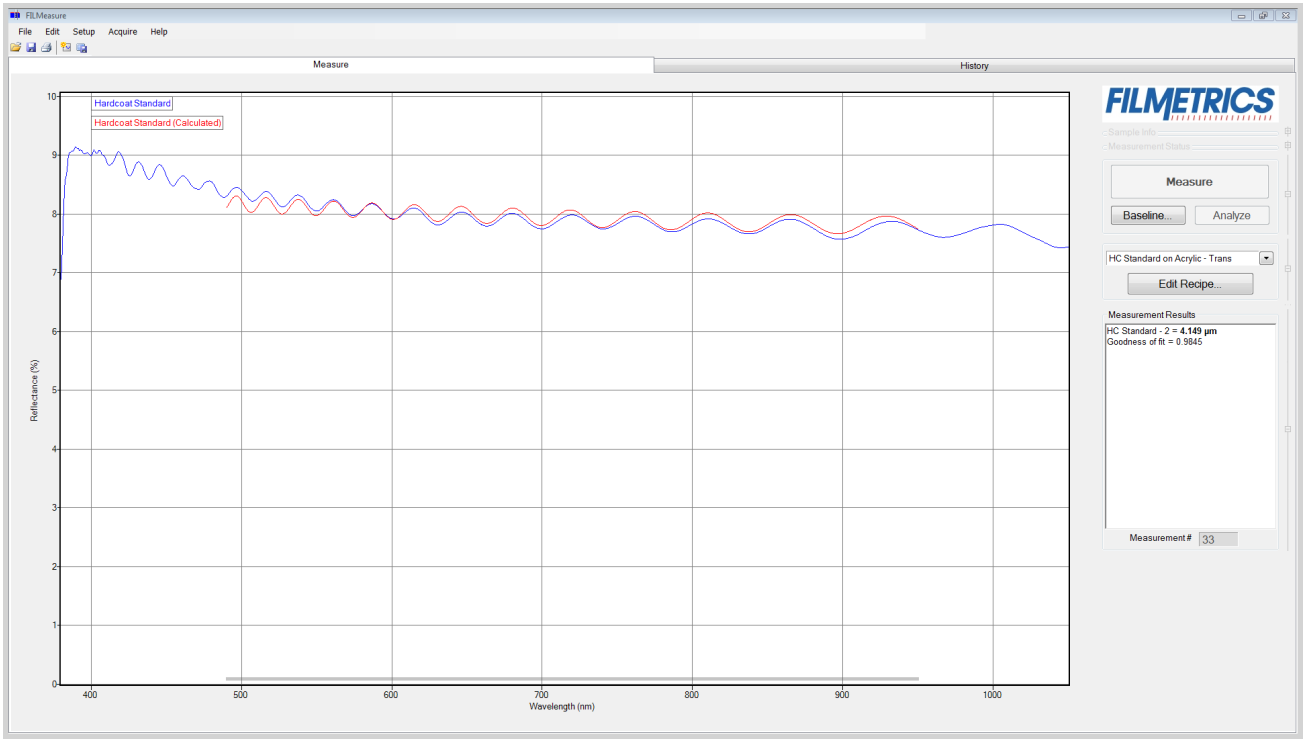
The second layer should be Acrylic - 2 with a thickness of 2000 µm, or 2 mm, with Air as the substrate. Do not enable solving for the Acrylic - 2 layer. This lets the software know that there is a finitely thick layer of acrylic, so that it will accurately account for back reflections. Click **OK** to confirm the changes to the recipe.

Step 3: Take a Baseline Measurement

Take a baseline measurement by first clicking on the **Baseline** button on the main screen. A dialog box will appear to guide you through the process. Follow the steps on screen, and be sure to match the material selected with the reflectance standard that will be used. For this example, use the BK7 reflectance standard. If you're having trouble focusing, and your microscope has a field stop, you can use **this guide** to help focus your system. Otherwise, the edge of the BK7 or any surface scratches can be used to help focus the system.

Step 4: Make the Measurement

Make the measurement by placing your sample on the stage and then click on the **Measure** button. FILMeasure will then acquire the reflectance spectrum and calculate the corresponding thickness. If the measurement was successful, the minima and the maxima of the calculated reflectance (the red line on the graph) will coincide in wavelength with the minima and the maxima of the measured reflectance (the blue line on the graph). In most cases they will not overlap, but will be separated in amplitude.



Measured and calculated reflectance spectra when measuring the TS-Hardcoat-Trans.

If the calculated (red) and measured (blue) minima and maxima do not coincide, then the measurement was not successful. There are several possible causes of an unsuccessful measurement. The most common for this type of measurement are described in **Cases #1**, **#2**, and **#3**, in the **Troubleshooting** section.

Measuring Thickness and Refractive Index

The following example describes the most common setup for refractive index and thickness measurement.

Example 1: Measuring Thickness and Optical Constants of a Film.

Example 1: Measuring Thickness and Optical Constants of a Film

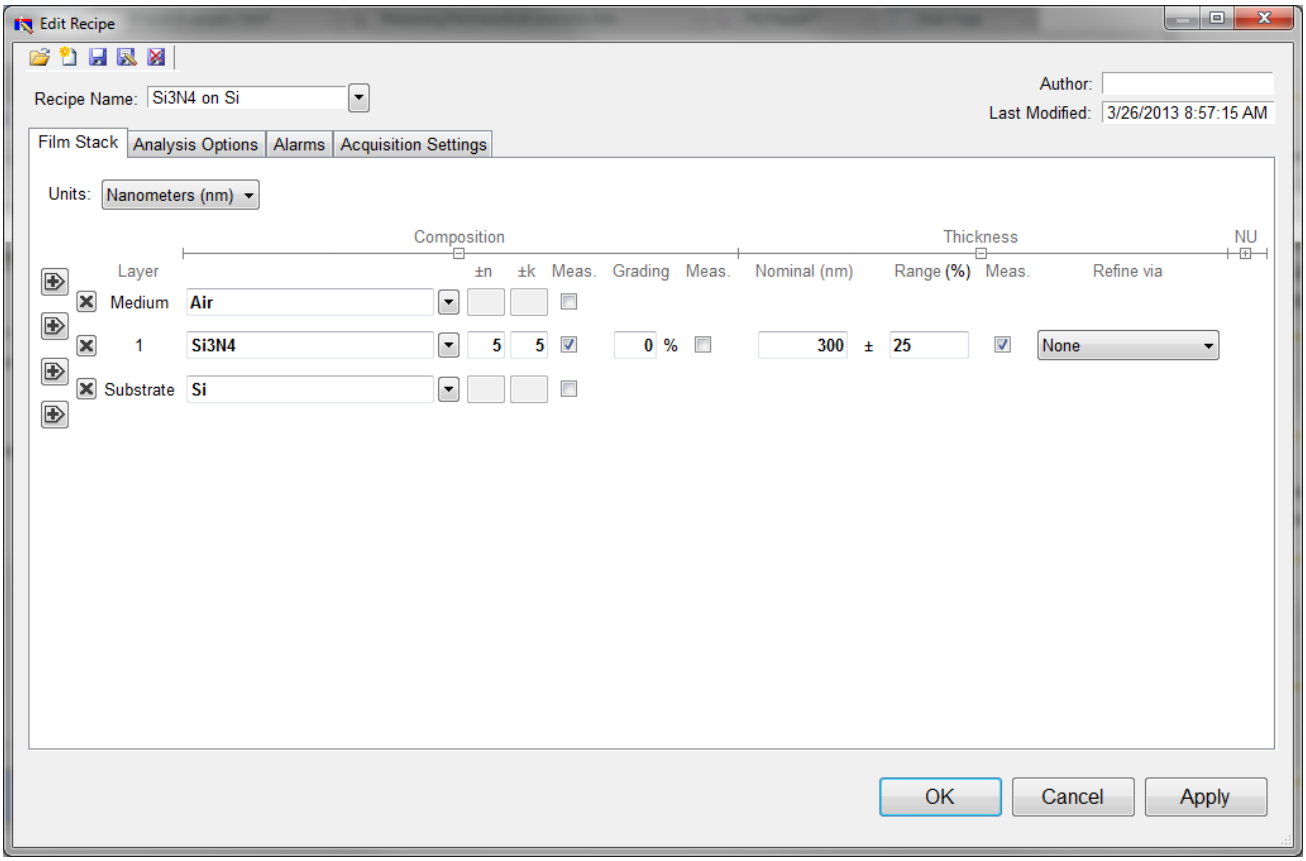
In this example we will demonstrate the measurement of Si3N4 on silicon. This type of measurement has an extremely broad range of applications, including the measurement of oxides, polysilicon, and optical coatings.

Step 1: Select the Film Recipe

Select the film structure to be measured, in this case “Si3N4 on Si”, from the **Recipe**: list box on the main screen. If the structure to be measured does not exist, a new structure must be defined. See **Editing Film Recipes** for more details.

Step 2: Edit the Film Recipe

To edit the film stack, click the **Edit Recipe...** button to open the dialog box. Check to see that the film stack matches that of the actual sample. If not, different films can be selected using either the drop-down menu next to the material or the **Search** function. This is also where you can enter a starting guess for thickness as well as the desired constraint range.



Example **Edit Recipe>Film Stack** window for measuring the thickness, n, and k of films on an opaque substrate.

For this example, we'll use 300 nanometers (nm) as the **Nominal** thickness, with a constraint range of 25%. **None** should be selected underneath the **Refine via** drop-down list. Make sure that the Si3N4 layer thickness is being solved for by clicking the checkbox under **Meas**.

We will also have to enable optical constants solving under the **Composition** options. These options should be visible by default, but if they are not they can be accessed by clicking on the [+] underneath **Composition** in the **Film Stack** tab. Left-click on the **Meas.** button to enable optical constants solving, and set the constraints for both n and k at 5. We'll also want to confirm that the correct model is selected. Right-click on the **Meas.** button to access the nk model drop-down list, and select the Si3N4 model. For more information on optical models, see **nk Model**.

The substrate should be set to Si. Underneath the **Analysis Options** tab, set the **Analysis Method** to **Exact**, with nothing else enabled. Click **OK** to confirm the changes to the recipe.

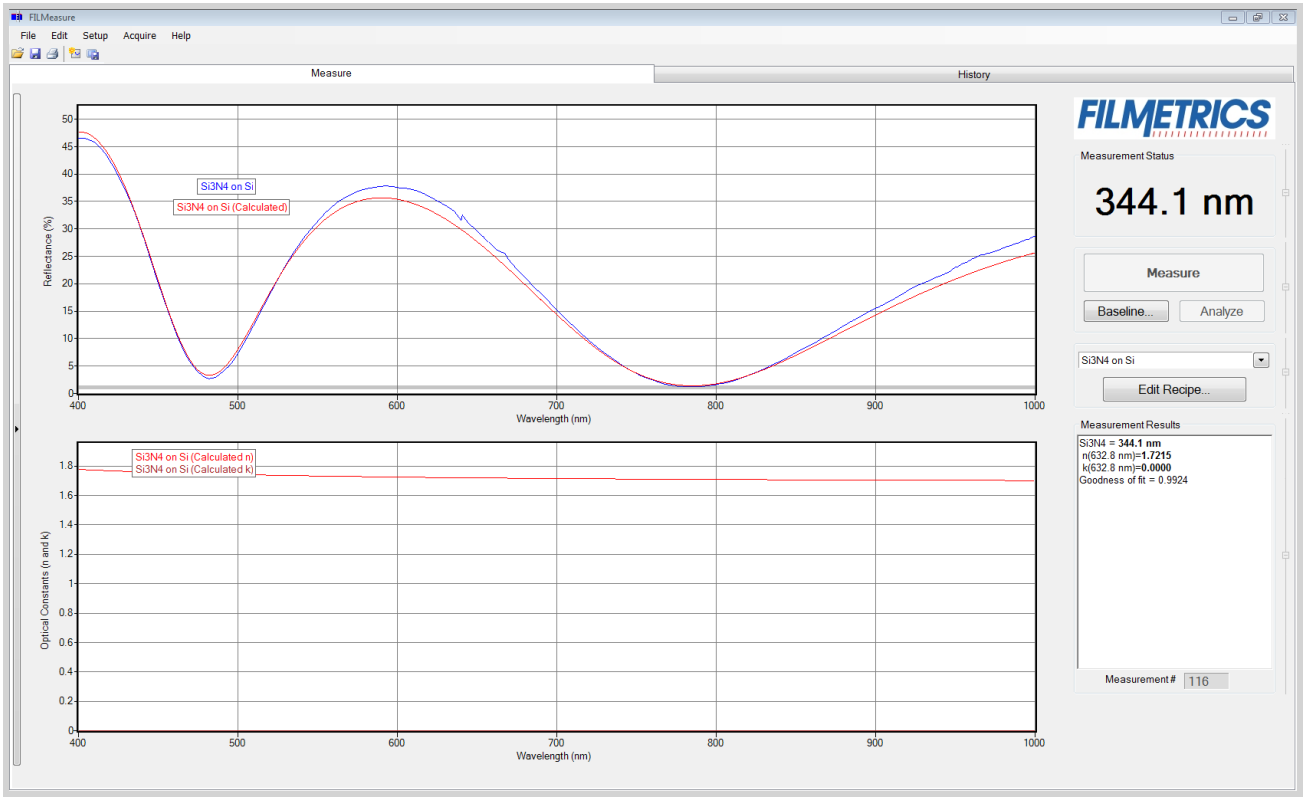
Step 3: Take a Baseline Measurement

Take a baseline measurement by first clicking on the **Baseline** button on the main screen. A dialog box will appear to guide you through the process. Follow the steps on screen, and be sure to match the material selected with the reflectance standard that will be used. For this example use the Si reflectance standard. If you're having trouble focusing, and your microscope has a field stop, you can use **this guide** to help focus your system.

Step 4: Make the Measurement

Make the measurement by placing your sample on the stage and then click on the **Measure** button. FILMeasure will then acquire the reflectance spectrum and calculate the corresponding thickness and optical constants. If the measurement was successful, the calculated reflectance (the red line on the graph) will coincide with the measured reflectance (the blue line on the graph).

If the measured and calculated spectra do not fall on top of each other, the resulting thickness, n, and k values are incorrect. If the mismatch between measured data and calculation is only slight, the results reported will only be off by a small amount. If the measured and calculated spectra match, but the results are implausible there may be a problem with the sample positioning and light collection. Causes and corrective actions to improve the measurements are listed in **Cases #4** and **#5** in the **Troubleshooting** section.



Measured and calculated reflectance spectra when measuring the thickness, *n*, and *k* of Si3N4 on silicon

Measurement Assumptions

The following assumptions must be valid if accurate measurements are to be made with the F40:

1. Every film present in the structure is specified in the **Edit Recipe** dialog box. This includes every film present in the sample including so-called adhesion films, oxide films (unless they are less than 20 Å or greater than 500 microns thick), and films on the bottom surface of the substrate if the substrate is transparent.

2. If the film is nonuniform, it has been accounted for in the recipe.

3. The light source has been allowed to warm up for at least 5 minutes if measuring thickness of films greater than 250nm, or 15 minutes if measuring thickness of films less than 250nm, refractive index, or reflectance.

In addition, the following assumptions are made if optical constants and/or very thin films (<500 Å) are to be measured:

4. If any grading is present (i.e. the refractive index and extinction coefficient are constant as a function of depth and constant over the entire spot being measured), it has been accounted for in the recipe.

5. The sample is flat. (The vacuum port may help in this case when samples are warped.)

6. No changes to the measurement system (such as fibers being moved) or light source have occurred since the acquisition of the most recent baseline.

7. No significant changes in room temperature (> 5 degrees F) have occurred since acquisition of the most recent baseline.

If any of the above assumptions are not true, it may still be possible to make a measurement, but accuracy may be degraded.

Hints for Improved Accuracy

This section contains various tips to help improve accuracy in your measurements.

Roughness.

Restricting the wavelength range of the analyzed reflection spectra.

Measuring thickness when the approximate thickness is not well known.

Measuring photosensitive films.

Roughness

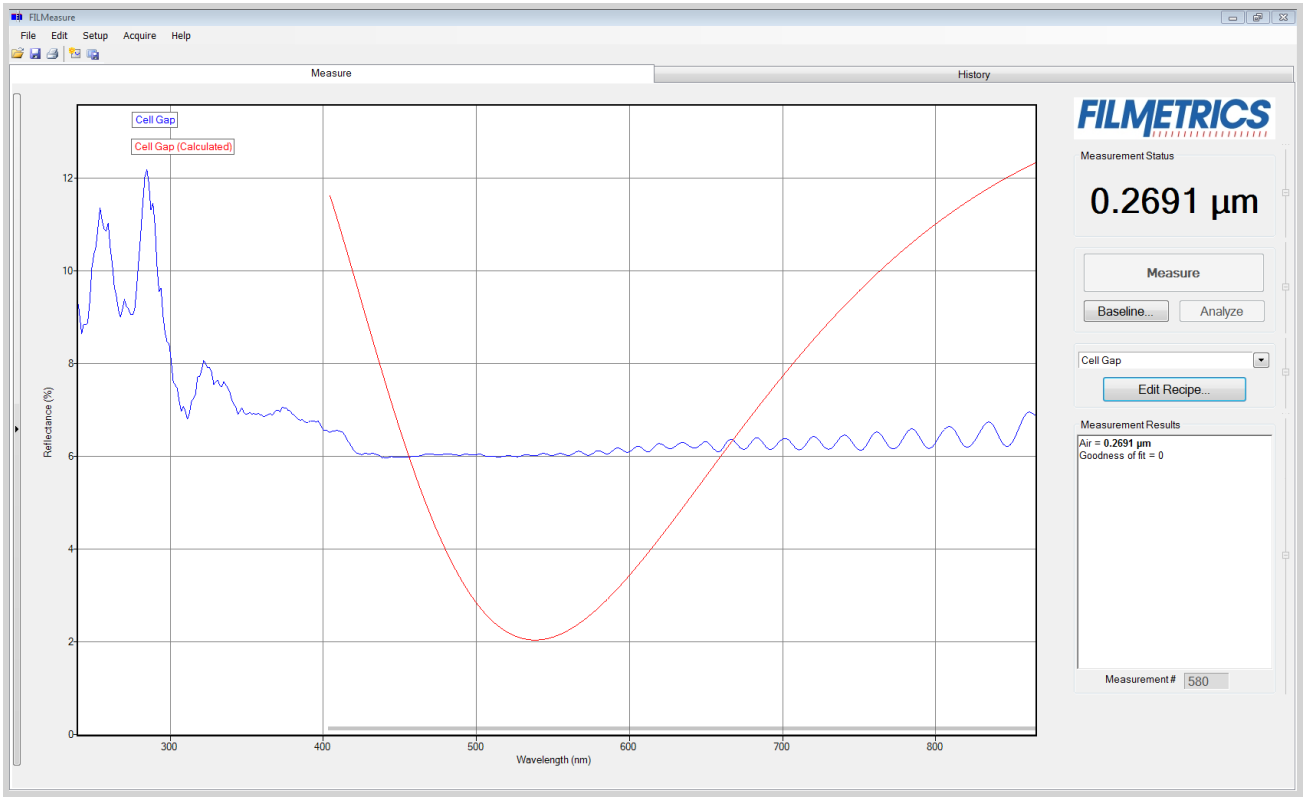
Slight amounts of surface or interface roughness that may be present can decrease the **GOF** value of a measurement. Entering a value or solving for roughness can partially account for this roughness so that a better **GOF** may be achieved. Generally, roughness is only present when the sample surface looks hazy at the measurement spot. The fact that haze can be seen means that there is scattered light. (A perfectly smooth surface will scatter no light, and thus the measured spot will not be visible.) Usually roughness less than 2.5 nm will not be visible, while roughness greater than about 25 nm will be extremely hazy.

FILMeasure assumes a Gaussian distribution of the surface height irregularities about the mean and it assumes that the roughness is small compared to the wavelength. FILMeasure reports the rms roughness value.

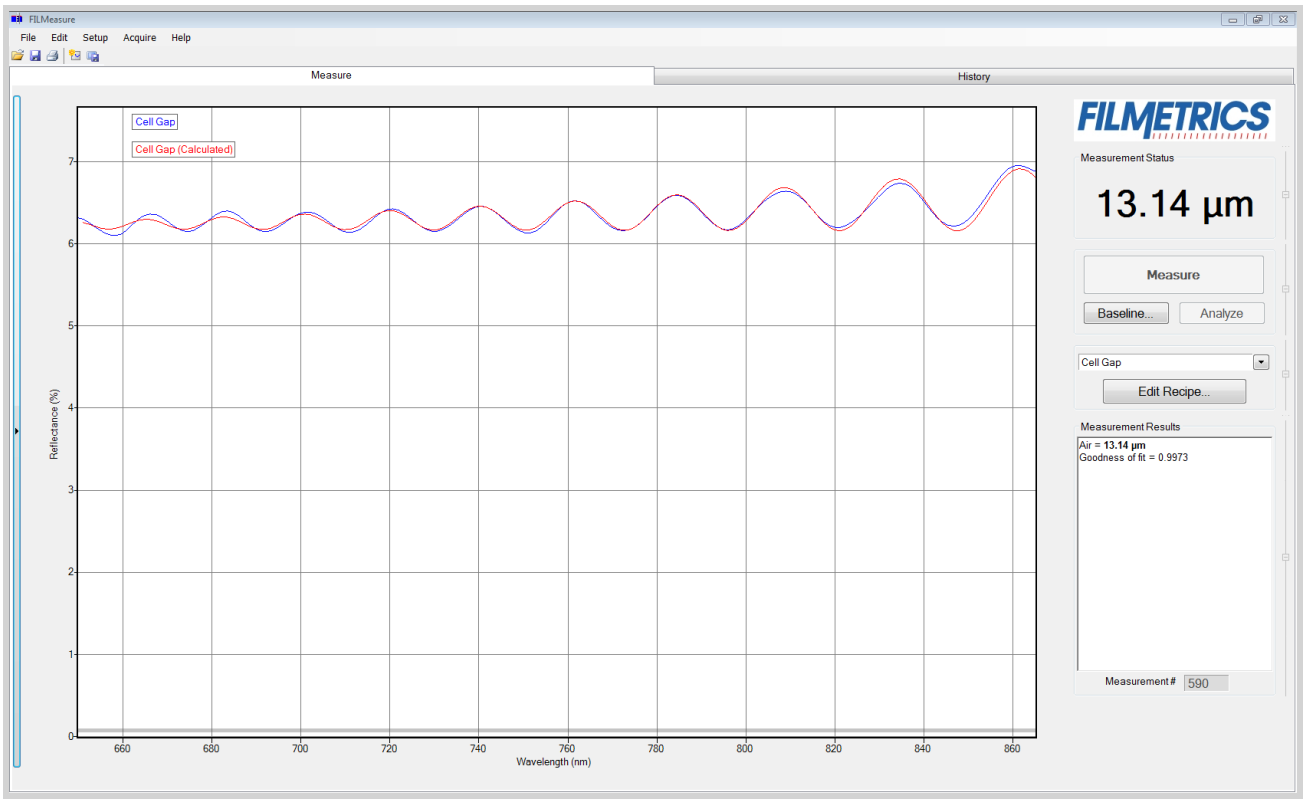
Restricting the wavelength range of the analyzed reflectance spectrum

Occasionally spectra from measured films are adversely affected by factors such as absorbing dyes, birefringence, or nonuniformity – all of which are difficult to model properly. It is often still possible to make accurate thickness measurements of these films by analyzing only unaffected portions of the spectra. The portion of the spectrum that is used to calculate film properties is determined by in the recipe underneath the **Analysis Options** tab.

You can also adjust the wavelength analysis range in the main FILMeasure window using the gray bar at the bottom of the graph. Click and drag either end of the bar to a new position on the x-axis to adjust the analysis range.



Example of a non-ideal film (spectrum with no oscillations at lower wavelengths) that requires reduced wavelength range for accurate measurement.



Example of a reduced wavelength range for measuring thickness of non-ideal films.

Measuring thickness when the approximate thickness is not well known

Unless otherwise specified, FILMeasure will determine a film's thickness by finding the best answer within about 1000 Å of the initial (user supplied) value. If the approximate thickness of the film is not known to better than about 1000 Å, then the **Grid** method or the **Fourier Transform** method of determining approximate thickness may be applied. See **Editing Film Structures** for more details.

Measuring photosensitive films

For layers such as unexposed photoresist that cannot be exposed to short-wavelength light, a filter may be inserted in the slot on the light source.

Note: this filter may only be inserted on systems using the SS-Microscope-VISNIR-1, SS-Microscope-UV-1, or SS-Microscope-UVNIR-1.

Troubleshooting

For error messages or hardware problems encountered with your Filmetrics instrument, please use the chart below to best diagnose your problem. For help with modeling, see **Troubleshooting - Thickness Modeling**.

Question 1: Are you able to start FILMeasure without an error message?

No: Continue to **Question 2**.
Yes: Continue to **Question 1-1**.

Question 1-1: What sort of problem are you seeing?

1: The lamp doesn't turn on or the fan isn't working properly. See the **Non-Operating Box, Lamp, or Fan Troubleshooting Guide**.
2: I get an error message when I click on something. Continue to **Question 1-1-2**.
3: Measurement results are wrong or unstable, after they had been good. See the **Measurement Results are Incorrect or Unstable Troubleshooting Guide**.
4: Measurement and/or baseline takes longer than it used to. See the **Slow Operation Troubleshooting Guide**.

Question 1-1-2: If you're still seeing an error after you've power cycled and installed new software, then select the description which most closely describes your error.

1: The error occurs during the baseline. See the **Error Message During Baseline Troubleshooting Guide**.
2: Some other error. See the **Error Messages -Miscellaneous Troubleshooting Guide**.

Question 2: Are you able to launch FILMeasure but it shows an error?

Yes: Continue to **Question 2-1**.
No: Then you need to install the software that come with your new system, or you can request new software. See the **Software Reinstallation Guide**.

Question 2-1: Does the error message start with "No Filmetrics instruments detected...."?

Yes: See the **Non-Operating Box, Lamp, or Fan Guide**.
No: See the **Error Messages - Miscellaneous Troubleshooting Guide**.

Power Cycling

Over the years we've found that about a third of support issues can be resolved by simply power cycling the Filmetrics system and computer. Follow the simple steps below to power cycle your instrument. Further assistance may be received by contacting us using the methods described in the **Contact Information** section.

Step 1: Shut down FILMeasure (it's OK in the rare case that you can't).

Step 2: Unplug all electrical connectors from the back of your Filmetrics box.

Step 3: Restart your computer, giving it time to load all drivers.

Step 4: Reconnect the electrical connections to your Filmetrics box. (Make sure that the power cord is getting power, and that any switch near the power connector is turned on.)

Step 5: Restart FILMeasure

Software Reinstallation Guide

Follow the steps below to reinstall FILMeasure. Further assistance may be received by contacting us using the methods described in the **Contact Information** section. *Warning: Upgrading software versions may result in slightly different (<1%) measurement results due to continual improvement of our solving algorithms and material files.*

Step 1: Shut down FILMeasure (it's OK in the rare case that you can't).

Step 2: Unplug all electrical connectors from the back of your Filmetrics system.

Step 3: Are you installing this software on a computer which already has FILMeasure installed?

Yes: Go to Step 4.

Yes: Jump to **Step 6.**

Step 4: Make a backup copy of your recipe and material files:

FILMeasure versions 1 thru 4: Backup the directory `C:\Program Files\FILMeasure`

FILMeasure versions 5 and up:

On Windows XP: Backup the directory `C:\Documents and Settings\All Users\Application Data\Filmetrics`

Note: The application Data folder may be hidden by default.

On Windows 7/8/Vista: Backup the directory `C:\Program Data\Filmetrics\`

Note: The Program Data folder may be hidden by default.

Step 5: Uninstall the current version of software:

On windows XP: Click Start > Control Panel > Add or Remove Programs > FILMeasure > Uninstall

On Windows 7/Vista: Click the Start orb > Control Panel > Programs and Features > FILMeasure > Uninstall

On Windows 8: Control Panel > More settings > Programs and Features > FILMeasure > Uninstall

Step 6: Run the software installer and follow installer instructions.

Note: you will need administrative privileges to install the software.

Step 7: Reconnect your Filmetrics system.

*Note for Windows XP: The "New Hardware Found" wizard may appear if your instrument has a USB connection. You **must** click "Next and complete the driver installation process. This dialog box may appear multiple times depending on the system configuration.*

Note for Windows 7/8/Vista: An Information balloon may appear over the taskbar while drivers are being installed. Please wait until the balloon indicates the drivers have been installed before starting FILMeasure.

Step 8: Run the software to verify the installation was successful.

Non-Operating Box, Lamp, Or Fan

Follow the steps below to troubleshoot symptoms of a non-operating spectrometer, light source, or fan. These are usually caused by having too much or not enough light. Further assistance may be received by contacting us using the methods described in the **Contact Information** section.

Step 1: Does the green LED on the right side of the front panel illuminate?

Yes: Jump to **Step 3**.
No: Go to Step 2.

Step 2: Is the power cord fully inserted into the back of the unit and a powered wall outlet? If your unit has a rear power switch, is it on?

Yes: Go to Step 3
No: Plug into a powered outlet or switch on the unit

Step 3: Does the LED light on the light source switch illuminate when switched on?

Yes: go to Step 4
No: Possible faulty switch or faulty indicator lamp, contact **Filmetrics**.

Step 4: Is the cooling fan spinning? Determine this by listening to the cooling fan which is located directly below the light source. (You'll need to get close to hear the fans on systems built after 2010.) For F50 systems the chassis cooling fan is louder than the light source cooling fan. You'll need to get close to the light source to hear the light source cooling fan.

Yes: Go to Step 5.
No: The cooling fan needs replacement, contact **Filmetrics**. *Note: a bad cooling fan can draw enough power to prevent the light source and box from operating properly.*

Step 5: Does the light source illuminate?

Yes: Go to Step 6
No: The lamp has burned out. Please replace the lamp following the instructions **here**. A spare lamp is included with most systems and additional lamps may be purchased on our website **www.filmetrics.com***Note: users can confirm a halogen bad lamp by removing it and checking it for electrical continuity.*

Step 6: The following steps are to troubleshoot a box that is not being detected by the FILMetrics software. This could be a software driver or (rarely) a hardware problem. To see what hardware your computer is detecting, look in the windows device manager. (instructions on how to access the Device Manager are included at the end of this document.)

In the Device Manager, which device do you see?

"Filmetrics Measurement Instrument" or similar: In this case the system should be operation correctly. If not, please contact **Filmetrics**.

"Unknown Device" or similar: The hardware appears to be operating properly, but the drivers for the hardware are not installed. If you have already power cycled and installed the most current Filmetrics software, please contact **Filmetrics** for further assistance.
Neither of the above: The hardware is not working properly. Go to Step 7

Step 7: Try a new USB cable and plug it into a different USB port. Does this fix the problem?
Yes: Either the USB cable or port was bad.
No: The USB controller inside the FILMetrics box may be bad. Please contact **Filmetrics**.

Accessing Device Manager in Windows 7:

1. Click on the Start Orb.
2. In the Star Search box type: device manager. Press enter.
3. Select Device manager from the list.
4. You should see a Filmetrics Measurement Instrument tab. Expand the tab and the appropriate driver should be listed for the Filmetrics instrument.

Accessing Device Manager in Windows XP:

1. Click Start.
2. Click on Control Panel
3. In the Control Panel double-click the Systems icon.
4. In the Systems Properties window click on the Hardware tab.
5. In the Hardware tab click the Device Manager button.
6. You should see a Filmetrics Measurement Instrument tab. Expand the tab and the appropriate driver should be listed for the Filmetrics instrument.

Error Message during Baseline

Follow the steps below to troubleshoot error messages encountered while taking a baseline. These are usually caused by having too much or not enough light. Further assistance may be received by contacting us using the methods described in the **Contact Information** section.

Step 1: Which error message are you seeing while taking a baseline?
Received light signal is too bright: If you are manually setting the integration time (see **Measurement Timing**) then you need to reduce the integration time. Otherwise you can reduce the light source intensity by using a flattening or neutral density filter. Optical filters can be purchased on our website, **www.filmetrics.com**.
Baseline Failure. Reference and background spectra are almost the same: This error is often caused by using the reference sample during the background step or vice versa, and is easily corrected by taking retaking the baseline while providing the proper material for the proper step. If this is not the case, go to Step 2.
Spectrometer peak intensity is x% of previous reference intensity: This error is often caused by using the incorrect reference sample and is easily corrected. If this is not the case, jump to **Step 5**.

Step 2: Does the light source illuminate?
Yes: Go to Step 3.
No: Check the **Non-Operating Box, Lamp, Or Fan Troubleshooting Guide**.

Step 3: Check to see if there is a broken or misconnected fiber. With the light source on, confirm that the illumination fiber is screwed into the light source securely, and that plenty of light is exiting the fiber at the far end near where the sample is placed. The light can be seen by placing paper (e.g., business card) near the sample location (do not look directly into the fiber if you are using a UV source). If plenty of light is seen, next check the return fiber by removing it from the spectrometer input and connecting it to the light source (removing the other fiber first of course). You should see light at the far end as before, but it may be 3-4 times smaller and dimmer. Did you see light at the sample end using both fibers in the light source?

Yes: The fiber appears to be good. Replace the fibers securely in their original positions (there will be a white band on the light source fiber if the two ends are different) and go to Step 4.

No: The fiber optic may be broken. Replacements can be purchased on our website, **www.filmetrics.com**

Step 4: Does your system have multiple spectrometers (i.e. EXR or UVX)

Yes: Check the Acquisition Settings tab under Edit Recipe to make sure that your fiber optic configuration matches the enabled spectrometers. Do this by making sure that each enabled spectrometer has a fiber attached to it (or disable a spectrometer that is not being used).

No: If you are still experience problems, please contact us using the **Contact Information** section.

Step 5: Was the correct reference selected from the drop-down list?

Yes: Go to Step 6.

No: Re-baseline using the correct reference.

Step 6: Has the light source lamp recently been changed?

Yes: This error is an expected response, no further action required

No: Go to Step 7.

Step 7: Has the optical configuration been altered (i.e. switching from standard spot size to small spot optics or a contact probe)?

Yes: This error is an expected response, no further action required

No: If you are still experiencing problems, please contact us using the **Contact Information** section.

Measurement Results are Incorrect or Unstable.

Follow the steps below to troubleshoot when measurement results are incorrect or unstable after the results had been good for some time. Additional help troubleshooting general measurement issues may be found in the **Troubleshooting: Thickness Modeling** section. Further assistance may be received by contacting us using the methods described in the **Contact Information** section.

Step 1: First confirm that you have selected the correct recipe for the sample that you are measuring (i.e., the same recipe that previously was giving good measurements). *Note that this troubleshooting guide does not cover instances where recipe parameters have been changed.*

Step 2: Confirm that the light source is turned on and that the fibers are securely tightened into the light source and the spectrometer input Place a piece of paper at the sample measurement location and confirm that you can see a light beam. Can the light beam be seen?

Yes: Jump to **Step 4**

No: Go to Step 3

Step 3: Is there light coming out of the light source? (If you are checking a UV light source, put on the goggles that were supplied with the light source before checking.)

Yes: It appears the fiber may be broken. Replacements can be purchased on our website **www.filmetrics.com**

No: Replace the lamp following the instructions **here**. A spare lamp is included with most systems and additional lamps may be purchased on our website **www.filmetrics.com***Note: users can confirm a halogen bad lamp by removing it and checking it for electrical continuity.*

Step 4: Perform a new baseline, paying particular attention to making sure that you are using the proper reference and that it is clean and right side up.

Step 5: Put a known-good sample on the stage and perform a measurement. If the measurement is still not correct, go to Step 6.

Step 6: Your lamp may be weak and needs to be replaced. The best way to tell is to replace it with the instructions found **here**. A spare lamp is included with most systems and additional lamps may be purchased on our website **www.filmetrics.com**.

If you are still experiencing problems with a slow baseline after the proceeding steps, please contact us using the methods described in the **Contact Information** section.

Slow Operation Troubleshooting Guide

Follow the simple steps below to troubleshoot slow system operation. Further assistance may be received by contacting us using the methods described in the **Contact Information** section.

Step 1: When did you experience the slow operation?

During a baseline: Go to Step 2.

When I click Measure: Jump to **Step 7**.

Step 2: Slow baselines are generally caused by a low light level, which can have several causes. Does the light source illuminate (be sure it is switched on, and that the shutter is open on UV systems)

Yes: Go to Step 3.

No: Check the **Non-Operating Box, Light, or Fan Troubleshooting Guide**

Step 3: Check to see if there is a broken or misconnected fiber. With the light source on, confirm that the illumination fiber is screwed into the light source securely, and that plenty of light is exiting the fiber at the far end near where the sample is placed. The light can be seen by placing paper (e.g., business card) near the sample location (do not look directly into the fiber if you are using a UV source). If plenty of

light is seen, next check the return fiber by removing it from the spectrometer input and connecting it to the light source (removing the other fiber first of course). You should see light at the far end as before, but it may be 3-4 times smaller and dimmer. Did you see light at the sample end using both fibers in the light source?

Yes: The fiber appears to be good. Replace the fibers securely into their original positions on the spectrometer box and light source (there will be a white band on the light source fiber if the two ends are different) and go to Step 4.

No: The fiber optic may be broken. Replacements can be purchased on our website, **www.filmetrics.com**

Step 4: Does your system have multiple spectrometers (i.e. EXR or UVX)

Yes: Check the Acquisition Settings tab under Edit Recipe to make sure that your fiber optic configuration matches the enabled spectrometers. Do this by making sure that each enabled spectrometer has a fiber attached to it (or disable a spectrometer that is not being used).

No: Go to Step 5.

Step 5: It may be that your lamp is old and needs to be replaced. The best way to tell is to replace it with the instructions found **here**. A spare lamp is included with most systems and additional lamps may be purchased on our website **www.filmetrics.com**.

If you are still experiencing problems with a slow baseline after the proceeding steps, please contact us using the methods described in the **Contact Information** section.

Step 7: Unless the slow operation during measurement is a new problem, please confirm that your computer meets the minimum system requirements as listed here. If it doesn't, please upgrade your computer. Otherwise, go to Step 8.

Step 8: A measurement that takes a long time generally means that there is a large amount of processing being required to find a solution and this is usually cause by a non-optimal recipe setting. Please first confirm that you have selected the correct recipe for the film stack you are measuring.

Step 9: Open the recipe and make sure that you are not solving for too many parameters. Solving for one or two thicknesses or a thickness and index should only take a second or two, but in some circumstances the solving time can be increased 5-10x for each additional parameter. Solving for nonuniformity (or adding it to increase accuracy of other parameters) can be especially time consuming.

Step 10: If you are solving for more than one thick layer (i.e., >10 um), you can speed up the solving process by reducing the thickness constraint range (which can be safely reduced even more by using an accurate nominal thickness guess) or by switching from using the **Grid** solver to the **FFT** solver in the recipe.

If you are still experiencing problems with a slow measurement after the proceeding steps, please contact us using the methods described in the **Contact Information** section.

Error Messages - Miscellaneous Troubleshooting Guide

This guide provides extended information on error messages a user may encounter on rare occasion while using our software. Further assistance may be received by contacting us using the methods described in the **Contact Information** section.

Error during spectrum analysis/ unable to analyze spectrum.

This error is generally caused by a problem with the recipe constraints. Try adjusting the solver wavelength range, thickness constraint range, or starting thickness value. Also make certain that the starting thickness values have been entered using the correct units of measure specified for the recipe.

Spectrum saturated.

This error indicates that the sample measured is more reflective than the spectrometer was expecting. Reflectance data may not be accurate as a result. Take a new baseline to fix this problem.

Troubleshooting Thickness Modeling

In all cases it has been assumed that the user has read the **Measurement Assumptions** section, and that each criterion has been met.

Case #1: No oscillations, or portions of oscillations, are present in the measured reflectance spectrum.

Case #2: The measured reflectance spectrum has periodic oscillations across the entire screen, but its minima and maxima do not match up with the calculated reflectance.

Case #3: Two or more different, but nearly the same, thickness readings are obtainable from the same measurement location.

Case #4: Poor matches between the measured and calculated reflectance spectra when measuring thickness and optical constants.

Case #5: Several different answers, or one unreasonable answer, are found when measuring thickness and optical constants, even though a good match is found between the measured and calculated reflectance spectra.

Case 1: No oscillations, or portions of oscillations, are present in the measured reflectance spectrum.

There can be several possible causes.

1. The film may just be very thin (<200 Å), thus presenting no discernible oscillations or only one identifiable minima or maxima. The FFT solver will not be able to accurately analyze films without at least one discernible full oscillation, in general meaning a film less than 0.2 microns thick. Use one of the **Spectrum Matching** solver methods (**Robust**, **Exact**) to analyze very thin films.

2. If the film is very rough, non-uniform in thickness over the measurement area, or has a graded interface it may not support coherent optical interference and thus it may not be able to be measured. Try moving to a different measurement spot for a better signal.

3. An improper baseline measurement was taken, for example a thickness standard is presented as a reflectance standard. Re-baseline the system while taking care to select the proper reflectance standard and reference file.

Case 2: The measured reflectance spectrum has periodic oscillations across the entire screen, but its minima and maxima do not match up with the calculated reflectance.

The most common cause is that the initial thickness guess was considerably different than the actual film thickness, and due to the constraints on possible thicknesses, FILMeasure was unable to find the correct answer.

To better understand this, it helps to know that the number of oscillations on the screen is proportional to the film thickness. For example, if the measured spectrum has roughly twice the number of the oscillations that the calculated spectrum has, then the measured film is roughly twice the thickness of the calculated thickness. Using this information, the initial thickness guess and the thickness constraints can be set more appropriately in the **Edit Recipe** dialog box. Another possible cause is found in **Case #3** (incorrect dispersion).

Case 3: Two or more different, but nearly the same, thickness readings are obtainable from the same measurement location.

When this occurs usually the measured and calculated spectra match somewhat, but not very well across the entire spectra (i.e., the measured and calculated spectra match exactly only over a small wavelength range and then gradually walk off one another outside this wavelength range). When thickness is the only value being measured, this is normally caused by the refractive index of the measured layer not matching that used by FILMeasure, especially when the film is greater than one micron thick. Unless more accurate index values can be obtained, the best way to solve this problem is to restrict the wavelength range used in the analysis.

Case 4: Poor matches between the measured and calculated reflectance spectra when measuring thickness and optical constants.

There can be many causes of this problem, including those listed in **Case #1** and **Case #2** above. Most commonly when a poor fit between the spectra occurs, it is because:

1) The components of the film structure are not all included in the **Edit Recipe>Film Stack** dialog box. Adjust the recipe accordingly and reanalyze the spectrum.

2) Very inaccurate initial guesses for the film thickness(es) have been listed. Try a new nominal starting guess, or expand the thickness constraint range.

3) The optical constants listed in the **Edit Recipe>Film Stack** dialog box are far from the actual optical constants in the material. Try selecting a different but similar material file if one is present, for example switching from Acrylic to Acrylic - 2.

4) The film being measured has properties that are not taken into account by FILMeasure. Examples of these properties are graded interfaces and non-uniform films. You can enable solving for these conditions in the recipe.
Note: Enabling Nonuniformity solving will increase solving time.

Case 5: Several different answers, or one unreasonable answer, are found when measuring thickness and optical constants, even though a good match is found between the measured and calculated reflectance spectra.

This normally occurs when a large number of properties are being measured on a very thin film. In general, the thinner a film is the less unique information that can be obtained from it. To understand this, see **Theory of Operation**. To solve the problem, you can either:

A. Decrease the number of variables solved for.
B. Increase the amount of data provided to the solver (analyzing reflectance and transmittance at the same time, or using the multi-spectral solver).
C. Enable multiple **Solver Cycles** under the **Edit Recipe>Analysis Options> Advanced** dialog.

Advanced Features

This section describes how to create and edit material files within Windows Excel.

Creating and Editing *n* and *k* Files

Creating and Editing *n* and *k* Files

Creating new *n* and *k* files

New *n* and *k* files can be created by going to **Edit>Material Library…** Clicking the **New** button will allow the user to define a new material file. Once clicked, while the **Default Model** is selected, the user can manually enter wavelength versus n or wavelength versus k values.

The user can also select **Custom Model**. While this is selected, clicking on the **Model…** button allows the user to create *n* and *k* files using predefined mathematical models.

Once completed, clicking **Save As…** will save the new file as a custom material for later use.

Creating *n* and *k* files from a calculated spectrum

Files for *n* and *k* can be created directly from a calculated spectrum, where *n* and *k* are measured. Once a spectrum is analyzed, go to **File>Save Measured *n* and *k*…** This will save your *n* and *k* files as a custom material which can be loaded into the user recipe.

Editing *n* and *k* files

Existing material files can be edited by going to **Edit>Material Library…** There, the user can load a material file by clicking **Open**. Values can then be changed manually. Clicking **Save** will save over the original file for later use. Use **Save As** to save the edited file under a new name.

Converting Microsoft Excel files into FILMeasure *n* and *k* files

For wavelength versus *n* or wavelength versus *k* data saved in Excel (*.xls) format, the data can be directly saved as material files that can be read by FILMeasure.

For .nnn and .kkk files.

For both *n* and *k* files, the data should follow the format shown below, where the wavelength values, in units of nanometers, are in the first column, and the *n* or *k* values are in the second. Note that the version number (cell B1) refers to version of the file. For this cell, you can use 1. The material number (cell B2) refers to what material category the file corresponds to. The material categories (and their corresponding numbers) are: metal (1), semiconductor (2), insulator (3), photoresist (4), and other (5). By putting the correct value for the material number, the file will automatically be sorted into the correct category when selecting the material in the **Edit Recipe** window.

To save the file created by Microsoft Excel, go to **File>Save As…** For **Save as Type:** choose **CSV (Comma delimited) (*.csv)**. For n files, save the file as "**FILENAME.nnn**", and for k files, save the file as

"**FILENAME.kkk**" (FILENAME represents the name you wish to call the file; note that quotation marks must be used to enclose the filename in Excel to force the extension to **.nnn** or **.kkk**). The file can then be saved to the desktop, and **Imported** using the **File>Import>Material File** option

	A	B
1	Version	1
2	Material	3
3	206.6	1.543
4	226.7	1.5228
5	248.3	1.5084
6	265.2	1.5
7	280.3	1.494
8	302.2	1.4872
9	330.3	1.4805
10	361.1	1.4751

For .fitnk files.

The data should follow the format of shown below, where the wavelength values, in units of nanometers, are in the first column, index of refraction (*n*) in the second, and extinction coefficient (*k*) in the third.

The first few columns of the file should be identical to the figure below the only exception being cell B3 which should contain a number describing the material category. The material categories (and their corresponding numbers) are: metal (1), semiconductor (2), insulator (3), photoresist (4), and other (5).

To save the file created by Microsoft Excel, go to **File>Save As…** For **Save as Type:** choose **CSV (Comma delimited) (*.csv)**. Save the file as "FILENAME.fitnk" (FILENAME represents the name you wish to call the file; note that quotation marks must be used to enclose the filename in Excel to force the extension to .fitnk). The file can then be saved to the desktop, and **Imported** using the **File>Import>Material File** option

	A	B	C
1	Version	1	
2	Compat. Version	1	
3	Material	3	
4	File Information		
5	Wavelength (nm)	n	k
6	206.6	1.543	0
7	226.7	1.5228	0
8	248.3	1.5084	0
9	265.2	1.5	0
10	280.3	1.494	0
11	302.2	1.4872	0
12	330.3	1.4805	0
13	361.1	1.4751	0

Theory of Operation

This section describes how the instruments work and includes the theory the measurements are based on, specifics about the hardware, and more detail about the baseline measurement.

Measurement Theory

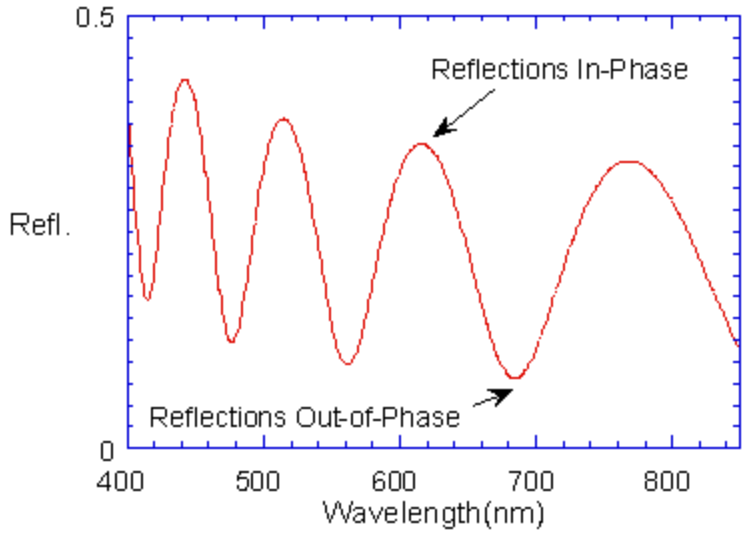
Thickness Measurement Details

Hardware Operation

The Baseline Measurement

Measurement Theory

Our instruments measure thin-film characteristics by either reflecting or transmitting light through the sample, and then analyzing this light over a range of wavelengths. Because of its wave-like properties, light reflected from the top and bottom interfaces of a thin film can be in-phase so that reflections add, or out-of-phase so that reflections subtract. Whether the reflections are in- or out-of-phase (or somewhere in between) depends on the wavelength of the light, as well as the thickness and properties of the film (e.g., reflections are in-phase when $\lambda = (2*n*d)/i$, where λ is the wavelength, n is the refractive index, d is the film thickness, and i is an integer). The result is characteristic intensity oscillations in the reflectance spectrum (see Figure below). In general, the thicker the film, the more oscillations there are in a given wavelength range.



Example of reflectance spectrum with oscillations.

The amplitude of the oscillations is determined by the refractive index and extinction coefficient of the films and substrate. Therefore, by analyzing the period and amplitude of these oscillations, our instruments can determine thickness of multiple thin films.

Thickness Measurement Details

Optical thin-film thickness measurements require the successful completion of two tasks: acquisition and then analysis of an accurate reflectance spectrum. To determine film thickness, FILMeasure calculates a reflectance spectrum that matches as closely as possible the measured spectrum. FILMeasure begins with an initial guess for what the reflectance spectrum should look like theoretically, based on the user's input of a film structure for the sample. Then FILMeasure varies the parameters it is solving for until the calculated reflectance spectrum matches the measured data. Mathematically, this procedure is complicated by the fact that as the thickness of the films in the calculation is varied there can be many near matches. Therefore, an approach that simply homes in on a solution by finding successively better approximations will not work unless the starting guess for optical thickness is within approximately 1000 Å if the actual thickness.

FILMeasure avoids homing in on a false solution by searching the entire acceptable thickness range to determine the thickness that gives the best possible match between the measured and calculated spectra. The thickness range searched is determined by the initial guess for thickness together with the thickness constraint. Since the time to find a solution is proportional to the range of thicknesses being searched it is beneficial to provide an initial guess for the thickness of the films to be measured.

F40 Hardware Operation

The F40 performs two distinct functions: data acquisition and data analysis. Data analysis specifics are discussed in **Software Overview**. In this section we describe how the F40 acquires accurate spectral reflectance data.

For systems using the F40 internal light source, light is supplied by a tungsten-halogen bulb that generates light from approximately 375 nm to 3000 nm. This light is delivered to and collected from the sample through a fiber-optic cable bundle and a lens. The intensity of the reflected light is measured at different wavelengths with a spectrometer. The F40 spectrometer uses a diffraction grating to disperse the light and a linear photodiode array to measure the light at the different wavelengths. After a user-selectable integration time, the accumulated charge in each photodiode is read by the computer. Because a longer integration time results in a larger charge, it is the integration time that determines the sensitivity of the spectrometer. Adjustment of the integration time is used to obtain the proper signal level. Too short of an integration time results in a weak, noisy signal, while too long of an integration time results in a saturated signal.

The Baseline Measurement

The baseline measurement allows the FILMeasure software to take into account the response inherent to the reflectance measurement hardware. It does this by measuring a reflectance standard and by taking a "dark" reading. In any optical system there are many components whose characteristics vary with wavelength (e.g., the output of the light source and the sensitivity of the spectrometer). However, when reflectance measurements are made, only variations in reflectance vs. wavelength due to the

sample under test are of interest. Therefore, FILMeasure must perform a calibration to determine the spectral response of the system. This is done by making a measurement of a reflectance standard that has known reflectance characteristics. Note that it is not necessary for the reflectance standard to be the same as the substrate upon which films to be measured reside. The only purpose served by the reflectance standard is to permit calibration of the optical system. For example, it is possible to use a Si wafer as the reflectance standard and then measure films on GaAs, InP, glass, plastic, etc.

After the reference measurement is made a dark reading is taken. A non-zero dark level is due to current leakage inherent to photodiodes, which causes each photodiode in the array to slowly charge up even when no light enters the spectrometer. Thus, in order to make an accurate measurement of the light entering the spectrometer, it is necessary to subtract this “dark” current contribution. This is the purpose of the background reading, which measures the magnitude of the dark current for a given integration time. When a “dark” measurement is made, a spectrum is measured that represents the signal generated by the spectrometer when a sample of zero reflectance is measured. To simulate a sample with zero reflectance during a “dark” measurement, a specularly reflecting sample can be held at an angle with the light source turned on, or in many cases the light source may simply be turned off momentarily during the dark measurement.

Due to drift in the light source and temperature of the spectrometer electronics, it is a good idea to take a baseline periodically.

How to Contact Us

We welcome suggestions from our users on ways to improve our software and hardware. Please send us any suggestions you may have for improvements in the help file or new features you would like to see in the software.

We may be reached by phone at +1-858-573-9300, by fax at +1-858-573-9400, by the Contact Us Now form on **our website**, or by e-mail at **support@filmetrics.com**.

Appendices

This section contains information on various topics as listed below:

Microscope Requirements

Performance Specifications

How to Replace the Light Bulb

Automation and Data

Software License Agreement

Microscope Requirements

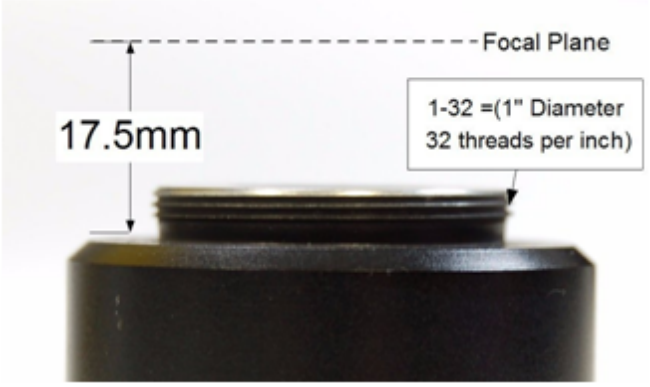
A microscope must have the following characteristics for proper F40 operation:

- Metallurgical microscope design (illumination delivered through the objective lens)
- Trinocular head with C-mount adapter (if Olympus, a BX-mount works too)
- No heat filter anywhere in the illumination path if light is desired above 700nm

The F40 attaches to the microscope by threading onto a C-mount. A C-mount is a standardized format and is by far the most common type of trinocular attachment found on microscopes. It is often used to attach video cameras. The C-mount specification defines both the mechanical attachment and the focal plane dimensions. The CCD camera mounts on the F40 adapter in order to see the measurement location on the sample.

The figure below shows a side view of a C-mount with the most important dimensions. The focal distance can be found by focusing the microscope on an object (as confirmed by looking through the eyepieces) and then using a business card or other piece of paper to locate the focus position above the flange. Sometimes a lever or rod must be pulled or turned to direct light up through the C-mount.

(Note that a less common mount is the CS-mount, which is the same as the C-mount except the focal distance is 12.5mm. The F40 is not compatible with the CS-mount.)



A powerful light source is required, typically at least 100 watts. Usually microscope light sources will filter out wavelengths above 700 nm by use of an in-line heat filter or a dichroic reflector integrated with an EKE lamp (this is done primarily to keep from heating the sample.) If light above 700 nm is desired, the in-line filter must be removed, or in the case of a dichroic reflector, the EKE lamp can be replaced with an aluminum reflector (a supplier can be recommended by Filmetrics.) Some care must be taken in this event because some fiber optic bundles use epoxy and can be susceptible to overheating.

Performance Specifications

Measurement Specs	**F40**	**F40-NIR**	**F40-EXR**	**F40-UV**	**F40-UVX**
Wavelength Range:	400-850 nm	950-1700 nm	400-1700 nm	200-1100 nm	200-1700 nm
Accuracy Greater of 0.4% or *:	2 nm	3 nm	2 nm	1 nm	1 nm
Precision[2]:	0.1 nm	0.2 nm	0.1 nm	0.1 nm	0.1 nm
Stability[3]:	0.07 nm	0.12 nm	0.07 nm	0.07 nm	0.07 nm
Thickness Range with 5x Objective[1]*	20 nm-20 µm	40 nm-40 µm	20 nm-40 µm	-	-
Thickness Range with 10x Objective:	20 nm-15 µm	40 nm-30 µm	20 nm-30 µm	-	-
Thickness Range with 15x Objective	20 nm-15 µm	40 nm-30 µm	20 nm-30 µm	4 nm-20 µm	4 nm-40 µm
Thickness Range with 50x Objective:	20 nm-2 µm	40 nm-4 µm	20 nm-4 µm	-	-
Thickness Range with 100x Objective:	20 nm-1.5 µm	40 nm-3 µm	20 nm-3 µm	-	-
Thickness Req'd to Measure n and k[1]*	100 nm	500 nm	100 nm	50 nm	50 nm

Spot Size	**Standard 500 µm Aperture**	**Optional 250 µm Aperture**	**Optional 100 µm Aperture**
5x Objective	100 µm	50 µm	20 µm
10x Objective[1]:	50 µm	25 µm	10 µm
15x Objective[2]:	33 µm	17 µm	7 µm

50x Objective	10 µm	5 µm	2 µm
100x Objective	5 µm	2.5 µm	1 µm

System Requirements:

PC: Windows XP(SP2) - Windows 8(64-bit)
Mac: OS X Lion/Mountain Lion running Parallels
Processor Clock Speed: 1.4 GHz min
Interface: USB 2.0

* Material and microscope dependent
[1] Using 5x objective.
[2] 1σ of 100 measurements of 1 µm SiO_2-on-Si.Value is average of 1σ over 20 days.
[3] 2σ of daily average of 100 measurements of 1 µm SiO_2-on-Si, measured over 20 days.

Specifications subject to change without notice.

Light Bulb Replacement

NOTE: These instructions apply to VIS, NIR, and EXR systems only. Please see the seperate users manual for the Deuterium & Tungsten-Halogen light source on UV and UVX systems.

* * Warning: * * Hazardous voltages are present within the unit. Never attempt any maintenance without disconnecting the power cord.

Step by step:

1. Exit FILMeasure program and turn off your computer.

2. Disconnect power cable from the back of the unit.

3. Disconnect fiber optic cables from the front of the unit.

4. Remove the two captive screws on the back panel opening the two halves of the enclosure.

* * Warning: * * Caution, avoid touching any interior components, other than the lamp, lamp base, and housing.

5. Pull the plunger behind the lamp all the way out.

6. Slide the lamp out of it holder, being careful not to touch the glass.

7. Unplug the old bulb from the lamp power connector.

8. Plug new lamp into the lamp power connector. Do not test lamp with lid removed.

9. Slide the new lamp into the holder, being careful not to touch the glass.

10. Gently release the plunger, holding the bulb in it's proper place. Do not test the bulb with the cover removed.

11. Replace the cover and tighten the screws.

Software Automation

Measurements can be automated and additional data analysis can be performed by user-supplied software. The mechanism by which this occurs is either by using the FIRemote class, which is part of FILMeasure.exe or by using the FIRemoteCOM dll. Accessing the FIRemote class directly using a .NET programming language such as Visual Basic .NET or C# offers the most flexibility, but requires the user be familiar with the Microsoft .NET software development environment. Alternatively, the FIRemoteCOM dll can be referenced from Microsoft Office programs and simple software procedures can be implemented there instead. The FIRemoteCOM dll includes fewer methods.

Methods, Property and Events:

New
AcquireSpectrum
ActivateChannelDisplayTab
AnalyzeSpectrum
AuthenticateRefBac
BaselineAcquireBackgroundAfterRef
BaselineAcquireReference
BaselineAcquireReferenceT
BaselineAcquireReferenceUsingOldSampleReflectance
BaselineAcquireSpectrumFromSample
BaselineCommit
BaselineSetRefMat
BaselineShowDialog
GUIVisible
HistoryDeleteAllResults
MeasChannelGuid
MeasChannelGuids
MeasChannelHWName
MeasChannelHWSerialNumber
MeasChannelName
Measure
NumberOfChannels
NumberOfSpectrometers
NumberOfSubSystems
OpticsConfiguration
OpenSpectrum
OpenSpectrumFromBuffer
RecipeInfo
SaveSpectrum
SaveSpectrumToBuffer
SetAnalysisWavelengthRange
SetMaterial
SetN
SetRecipe
SetRoughness
SetThickness

SpectrometerDiagnostics

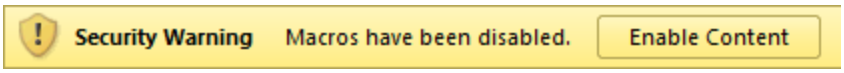
Less-Commonly-Used Methods

The following methods are only rarely used. Methods which refer to a System are used with the F32 and F37 thin film monitoring systems. Many methods accept either a measSystem or a measChannel guid. However, some methods are relevant only to a single channel. If you supply a measSystem guid as the argument for one of these methods, an exception will be thrown.

ActivateMonitorDisplayTab
BaselineExistsAndIsAuthenticated
GeneralPurposeIOIsSupported
GeneralPurposeIOReadValue
GeneralPurposeIOSetValue
MeasSystemGuid
MeasSystemGuids
MeasSystemHWName
MeasSystemName
NumberOfSystems
SetRecipeModeToSpectrumAnalysis
SetRecipeSpectrumAnalysis
ShutdownRequestedHandler
ShuttingDown
SystemAutoSave
SystemAutoSaveBaseFileNameAndPath
SystemMeasure
SystemStartMonitoring
SystemStopMonitoring
SystemMeasurementCompletedEventHandler

FIRemoteCOM dll

The dll is automatically included whenever FILMeasure or FILMapper is installed. Since the dll references the corresponding .exe file it is located inside the FILMeasure or FILMapper folder in the Program Files (or Program Files (x86) on 64-bit systems) path. The best way to learn how to use the dll is to examine the example Excel workbook that is included with the software. The workbook has the same name as the dll, but has the extension .xlsm and is located in the same folder as the dll. When you open the . xlsm file for the first time, you will see a warning banner as shown below.



You must click the Enable Content button in order to allow the code associated with the buttons on the worksheets to run. If you do not see the security warning when you open the spreadsheet, then you may need to modify settings in Excel using the Trust Center. The exact procedure varies, depending on which version of Excel you are using.

To see the example source code, click the Developer tab on the ribbon. Then click Visual Basic and double-click the ThisWorkbook object.

Reference for FIRemote Class:

Methods, Properties, and Events:

```
Public Sub AcquireSpectrum(ByRef spectrumWavelengths() As Single,
ByRef spectrumData() As Single)
```

arguments – Same as FIRemote Class

Remarks: See remarks for **AcquireSpectrum()** in FIRemote Class.

```
Public Sub Measure(ByVal formatSummaryAsRtf As Boolean, ByRef
measLayerThickness() As Single, ByRef measGOF As Single, ByRef
summary As String)
```

formatSummaryAsRtf – The measurement summary can be formatted as either plain text or as rtf. Formatting the summary as rtf is advantageous if it will be displayed to the user because then the full set of information including bold font and colors will be included.

measLayerThickness – Array containing thickness of all layers. Thickness of Layer 1 is in index 1 in the array.

measGOF – Measured Goodness Of Fit parameter.

Summary – Same as text which appears in Results area in Measure tab.
Remarks: See remarks for **Measure()** in FIRemote Class.

```
Public Sub SetRecipe(recipeName As String)
```

Arguments and Remarks – See documentation for **SetRecipe** in FIRemote Class.

FIRemote Class

FIRemote is exposed as a public assembly and is accessible using the Microsoft .NET programming environment. The best way to learn how to use the FIRemote class is to look at the example program and source code which are automatically installed as part of the FILMeasure software. Assuming that the FILMeasure program is installed in the default location, the example software can be found in C:\Program Files\Filmetrics\FILMeasure\SourceCode\FIRemoteTest. Additionally, an executable, FIRemoteTest.exe, is located in the FILMeasure folder. All of the available commands can be tested using FIRemoteTest.exe.

In order to set up a development environment for running and debugging code, the file system must be set up so that the FILMeasure.exe is located in the same folder as the client program that is being developed. Since FILMeasure expects to find its dependent files in the same directory as the executable, this means that the entire contents of the FILMeasure folder must be copied to the build output folder. For example, if the software development environment output folder is located in

C:\SourceCode\TestSln\TestPrj\bin\Debug\, then all the files and subfolders from C:\Program Files\Filmetrics\FILMeasure\ must be copied to C:\SourceCode\TestSln\TestPrj\bin\Debug\.

Some of the methods listed in the following reference a SystemGuid. In the terminology used in this document, a Measurement System is an object comprising one or more measurement channels, but with operations that can be performed simultaneously on all the channels in the system. The SystemGuid is used to distinguish between multiple simultaneously connected measurement systems. Examples of measurement systems with multiple measurement channels include the F32 and F37. Documentation for methods applying only to such measurement systems can be found in the Less Commonly Used Methods section. In addition, some methods will accept either a SystemGuid or a ChannelGuid. Such methods thus will execute an operation either on a single channel, or simultaneously on all channels of a system.

Note that the FIMeasResults object which is returned by the Measure and AnalyzeSpectrum methods has a large number of member functions and properties. Since the names are all self-explanatory, we have not attempted to list all of the members here. The reader should use the Object Browser which is built into Microsoft Visual Studio in order to discover the available properties and methods.

New

```
Public Sub New(ByVal showFILMeasureGUI As Boolean) (deprecated)
Public Sub New(ByVal showFILMeasureGUI As Boolean, ByRef
theConstructorWarning As ConstructorWarning, ByRef warningMessage As
String)(deprecated)

Public Sub New(ByVal guiType AsGraphicalUserInterfaceType, ByVal
guiStartupState AsGraphicalUserInterfaceStartupState, ByVal
guiWindowStartupState AsFormWindowState, ByRef theConstructorWarning
AsConstructorWarning, ByRef warningMessage As String)
```

guiType – Determines if the FIRemote user interface and associated objects will be constructed at startup. If `guiType` is set to `None`, then the startup process is accelerated and memory usage is minimized. However, the user interface cannot be displayed at a later time if it is not constructed during the startup process. If `guiType` is set to `Standard`, then the normal graphical user interface is constructed during the startup process.

guiStartupState – Determines whether or not the FIRemote user interface is displayed at startup. Note that this argument has no effect if `guiType = None`. If `guiStartupState` is set to `Hidden`, then the user interface will not be visible on screen at the completion of the startup process. If the user interface was constructed at startup, it can be displayed at a later time by setting `GUIVisible = True`.

guiWindowStartupState – If `guiStartupState` is set to `Shown` then the FIRemote User interface window will appear on the screen at the completion of the startup process. Note that this argument has no effect if `guiType = None`. The state of the window is controlled by `guiWindowStartupState`. You can set the state to `Maximized`, `Normal`, or `Minimized`.

theConstructorWarning – Returned value of type ConstructorWarning (`None` or `StartupRecipeLoadFailure`).

warningMessage – Returned warning message string. Empty if None.

Remarks: You can suppress the display of the FIRemote user interface by setting `guiType` appropriately. Typically, you would show the user interface during software development in order to aid in the testing and debugging process. However, there are some applications where it is useful to be able to show and hide the user interface while the software is running. This is accomplished with the GUIVisible Property. The constructor warns if the startup recipe has problems loading and a default recipe is loaded instead.

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AcquireSpectrum

```
Public Sub AcquireSpectrum(ByRef spectrumWavelengths() As Single,
ByRef spectrumData() As Single)
Public Sub AcquireSpectrum(ByRef spectrumWavelengths() As Single,
ByRef spectrumData() As Single, ByVal flushPipeline As Boolean)
Public Sub AcquireSpectrum(ByRef spectrumWavelengths() As Single,
ByRef spectrumData() As Single, ByRef secondarySpecWavelengths() As
Single, ByRef secondarySpecData() As Single, ByRef
primarySpecIsReflectance As Boolean)
Public Sub AcquireSpectrum(ByRef spectrumWavelengths() As Single,
ByRef spectrumData() As Single, ByVal secondarySpecWavelengths() As
Single, ByRef secondarySpecData() As Single, ByVal flushPipeline As
Boolean, ByRef primarySpecIsReflectance As Boolean)
Public Sub AcquireSpectrum(ByVal measChannelGuid As Guid, ByRef
spectrumWavelengths() As Single, ByRef spectrumData() As Single)
Public Sub AcquireSpectrum(ByVal measChannelGuid As Guid, ByRef
spectrumWavelengths() As Single, ByRef spectrumData() As Single,
ByVal flushPipeline As Boolean)
Public Sub AcquireSpectrum(ByVal measChannelGuid As Guid, ByRef
primarySpecIsReflectance As BooleanByRef spectrumWavelengths() As
Single, ByRef spectrumData() As Single)
Public Sub AcquireSpectrum(ByVal measChannelGuid As Guid, ByRef
spectrumWavelengths() As Single, ByRef spectrumData() As Single,
ByVal flushPipeline As Boolean, ByRef primarySpecIsReflectance As
Boolean)
```

measChannelGuid – The GUID of the measurement channel for which a spectrum should be acquired. If multiple measurement channels exist, the measChannelGuid must be specified.

spectrumWavelengths – Array to contain wavelengths of measured spectum data points.

spectrumData – Measured reflectance or transmittance data points.

secondarySpecWavelengths – For systems that can simultaneously acquire reflectance and transmittance such as the F10-RT, array to contain wavelengths of measured secondary spectum data points. For all other systems, the returned argument is Nothing.

*secondarySpecDat*a – For systems that can simultaneously acquire reflectance and transmittance such as the F10-RT, array to contain the measured secondary spectum data points. For all other systems, the returned argument is Nothing.

flushPipeline – If set to True (default), any data currently being acquired is ignored and new data is acquired. If set to False, data currently being acquired is returned when acquisition is finished.

primarySpecIsReflectance – Indicates whether the primary spectrum data is Reflectance or Transmittance.

Remarks: It is important that you catch exceptions which may occur as a result of calling this method. See the example program for details.

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ActivateChannelDisplayTab

```
Public Sub ActivateChannelDisplayTab(ByVal measChannelGuid As Guid)
```

measChannelGuid – The GUID of the measurement channel of the corresponding Measurement Tab to be selected.

Remarks: After execution, the active tab in the FILMeasure GUI will be the specified Measurement Tab. This method should only be executed if multiple measurement channels exist.

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AnalyzeSpectrum

```
Public Function AnalyzeSpectrum(ByVal formatSummaryAsRtf As Boolean)
As FIMeasResults
Public Function AnalyzeSpectrum(ByVal formatSummaryAsRtf As Boolean,
ByVal addToHistory As Boolean) As FIMeasResults
Public Function AnalyzeSpectrum(ByVal measChannelGuid As Guid, ByVal
formatSummaryAsRtf As Boolean) As FIMeasResults
Public Function AnalyzeSpectrum(ByVal measChannelGuid As Guid, ByVal
formatSummaryAsRtf As Boolean, ByVal addToHistory As Boolean) As
FIMeasResults
```

measChannelGuid – The GUID of the measurement channel for which a spectrum should be analyzed and optionally added to history. If multiple measurement channels exist, the measChannelGuid must be specified.

formatSummaryAsRtf – The measurement summary returned by the .ResultsSummary property of the FIMeasResults object can be formatted as either plain text or as rtf. Formatting the summary as rtf is advantageous if it will be displayed to the user because then the full set of information including bold font and colors will be included.

addToHistory – Normally, each analysis result is added to the collection of results displayed in the History area of FILMeasure. In some cases, it may be advantageous to suppress the addition of a result to the History area. One example where this may be needed is the case where you wish to analyze a spectrum with two different measurement recipes and then add only the best result to the History.

Remarks: The most-recently acquired spectrum can be analyzed by calling this function.

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AuthenticateRefBac

```
Public Sub AuthenticateRefBac()
Public Sub AuthenticateRefBac(ByVal measChannelOrSystemGuid As Guid)
```

measChannelOrSystemGuid – The GUID of the measurement channel for which a baseline should be recovered. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: Calling this method is equivalent to clicking Baseline… to display the Baseline dialog and then clicking Recover Last Baseline… to recover an old baseline spectrum. Note that there are many situations where an exception may be generated by calling this method. See the example program for details.

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BaselineAcquireBackgroundAfterRef

```
Public Sub BaselineAcquireBackgroundAfterRef()
Public Sub BaselineAcquireBackgroundAfterRef(ByVal
measChannelOrSystemGuid As Guid)
```

measChannelOrSystemGuid – The GUID of the measurement channel for which a background should be acquired. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: This method provides a means to automate what is most commonly called step #3 of the Baseline procedure (step #4 for F10-RT, “Reflection Only” or “Reflection and Transmittance”. step #2 for F10RT“Transmittance Only”). As the name of this method implies, you must have previously acquired a reference spectrum.

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BaselineAcquireReference

```
Public Sub BaselineAcquireReference()
Public Sub BaselineAcquireReference(ByVal measChannelOrSystemGuid As
Guid)
```

measChannelOrSystemGuid – The GUID of the measurement channel for which a reference should be acquired. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: This method provides a means to automate what is most commonly called step #2 of the Baseline procedure. Calling BaselineAcquireReference may generate an exception. There are a number of rules required for successful execution of this method. Unless the acquisition timing mode in the recipe is set to Manual, you must first call BaselineAcquireSpectrumFromSample. Alternatively, you could call the variant of this method which accepts a user-supplied reflectance value if you know the sample reflectivity and wish to skip step #1.

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BaselineAcquireReferenceT

```
Public Sub BaselineAcquireReferenceT()
Public Sub BaselineAcquireReferenceT(ByVal measChannelOrSystemGuid As Guid)
```

measChannelOrSystemGuid – The GUID of the measurement channel for which a Transmittance reference should be acquired. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: This method should only be called for the F10-RT. It provides a means to automate step #3 of the Baseline procedure for “Reflectance Only” or “Reflectance and Transmittance” modes, or step #1 of the Baseline procedure for “Transmittance Only” mode. No sample should be positioned on stage when called.

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BaselineAcquireReferenceUsingOldSampleReflectance

```
Public Sub BaselineAcquireReferenceUsingOldSampleReflectance()
Public Sub BaselineAcquireReferenceUsingOldSampleReflectance(ByVal measChannelOrSystemGuid As Guid)
```

measChannelOrSystemGuid – The GUID of the measurement channel for which a reference should be acquired. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: This method provides a means to automate steps 1 and 2 of the Baseline procedure by assuming that the sample reflectance is unchanged from what it was the last time a baseline procedure was performed. Note that an exception may be thrown in some situations including the case where no prior baseline spectrum exists.

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BaselineAcquireSpectrumFromSample

```
Public Sub BaselineAcquireSpectrumFromSample()
```

```
Public Sub BaselineAcquireSpectrumFromSample(ByVal
measChannelOrSystemGuid As Guid)
```

measChannelOrSystemGuid – The GUID of the measurement channel for which a sample spectrum should be acquired. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: This method provides a means to automate what is most commonly called step #1 of the Baseline procedure.

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BaselineCommit

```
Public Sub BaselineCommit()
Public Sub BaselineCommit(ByVal measChannelOrSystemGuid As Guid)
```

measChannelOrSystemGuid – The GUID of the measurement channel for which a new baseline should be commited. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: Call this method to finalize the baseline procedure and commit the acquired spectra for use as a new baseline measurement.

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BaselineSetRefMat

```
Public Sub BaselineSetRefMat(ByVal theRefMat As String)
Public Sub BaselineSetRefMat(ByVal measChannelOrSystemGuid As Guid,
ByVal theRefMat As String)
```

measChannelOrSystemGuid – The GUID of the measurement channel for which the reference material should be assigned. If multiple measurement channels exist, the measChannelGuid must be specified.

theRefMat – The reference material as it would normally appear in the list of reference materials shown in the Baseline dialog.

Remarks: This method should be called prior to acquiring a reference spectrum

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BaselineShowDialog

```
Public Sub BaselineShowDialog(ByRef dialogCanceled As Boolean)
```

dialogCanceled – True if user has canceled the dialog.

Remarks: Calling this method will cause the baseline dialog box to be displayed on the screen

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GUIVisible

```
Public Property GUIVisible As Boolean
```

Remarks: Setting this property to `True` will cause the FIRemote user interface to be displayed on the screen. Note that this will normally cause the user interface window to appear on top of any other windows. If you wish to keep another window on top of the FIRemote user interface window, it may be necessary to call .BringToFront on that other window. If the FIRemote object is constructed with `guiType` set to `None` then an exception will be thrown if `GUIVisible` is set to `True`.

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HistoryDeleteAllResults

```
Public Sub HistoryDeleteAllResults()
```

Remarks: All measurement results in the History tab are deleted. If the FIRemote object has no user interface (`guiType = None` in `New()`), then there is no measurement history and this function has no effect.

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MeasChannelGuid

```
Public ReadOnly Property MeasChannelGuid(ByVal measChannelIndex As
Integer) As Guid
Public ReadOnly Property MeasChannelGuid(ByVal measSystemGuid As
Guid, ByVal measChannelIndex As Integer) As Guid
```

measSystemGuid – The GUID of a measurement system.

measChannelIndex – The zero-based index of the measurement channel.

Remarks: Returns the GUID of the specified channel. Note this can be used to obtain the GUID used by all methods requiring a measChannelGUID. Also note that the relationship between measChannelIndex and MeasChannelGuid is not static. Future versions of FILMeasure will dynamically reorder this list in response to an equipment connect/disconnect event. You should not rely on the order of the channels in the list when attempting to perform a command on a certain channel.

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MeasChannelGuids

```
Public ReadOnly Property MeasChannelGuids() As Collection(Of Guid)
```

Remarks: Returns a collection of GUID for each measurement channel that exists.

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MeasChannelHWName

```
Public ReadOnly Property MeasChannelHWName(ByVal measChannelGuid As Guid) As String
```

measChannelGuid – The GUID of the measurement channel for which the channel hardware name should be returned.

Remarks: The hardware name is composed of a system name string and a serial number string separated by a colon. Example: F20:09A006.

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MeasChannelHWSerialNumber

```
Public ReadOnly Property MeasChannelHWSerialNumber(ByVal measChannelGuid As Guid) As String
Public ReadOnly Property MeasChannelHWSerialNumber(ByVal measChannelGuid As Guid, ByVal spectrometerIndex As Integer) As String
Public ReadOnly Property MeasChannelHWSerialNumber(ByVal measChannelGuid As Guid, ByVal subsystemIndex As Integer, ByVal spectrometerIndex As Integer) As String
```

measChannelGuid – The GUID of the measurement channel.

spectrometerIndex – The spectrometer index (to specify which of multiple spectrometers in the channel).

subsystemIndex – The subsystem index (to select among multiple subsystems in the channel).

Remarks: Returns the controller hardware serial number of the specified spectrometer. If the spectrometer or subsystem are not specified, the default index = 0 will be used. If there are multiple subsystems, a hyphen followed by the subsystem ID is appended to the hardware serial number. Example for single subsystem: 09A006. Example for multiple subsystem: 09A007-1

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MeasChannelName

```
Public ReadOnly Property MeasChannelName(ByVal measChannelGuid As Guid) As String
```

measChannelGuid – The GUID of the measurement channel for which the channel name should be returned.

Remarks: By default the channel name is the empty string.

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Measure

```
Public Function Measure(ByVal formatSummaryAsRtf As Booleanl) As
FIMeasResults
Public Function Measure(ByVal formatSummaryAsRtf As Booleanl, ByVal
addToHistory As Booleanl) As FIMeasResults
Public Function Measure(ByVal measChannelGuid As Guid, ByVal
formatSummaryAsRtf As Booleanl) As FIMeasResults
Public Function Measure(ByVal measChannelGuid As Guid, ByVal
formatSummaryAsRtf As Booleanl, ByVal addToHistory As Booleanl) As
FIMeasResults
```

measChannelGuid – The GUID of the measurement channel for which a spectrum should be acquired and analyzed. If multiple measurement channels exist, the measChannelGuid must be specified.

formatSummaryAsRtf – The measurement summary returned by the .ResultsSummary property of the FIMeasResults object can be formatted as either plain text or as rtf. Formatting the summary as rtf is advantageous if it will be displayed to the user because then the full set of information including bold font and colors will be included.

addToHistory – Normally, each analysis result is added to the collection of results displayed in the History area of FILMeasure. In some cases, it may be advantageous to suppress the addition of a result to the History area. One example where this may be needed is the case where you wish to analyze a spectrum with two different measurement recipes and then add only the best result to the History.

Remarks: Calling this function is equivalent to clicking the Measure button in FILMeasure. Note that if the Measure button is disabled when you call this function, an exception will be thrown.

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NumberOfChannels

```
Public ReadOnly Property NumberOfChannels() As Integer
```

Remarks: Number of measurement channels that exist.

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NumberOfSpectrometers

```
Public ReadOnly Property NumberOfSpectrometers(ByVal measChannelGuid
As Guid) As Integer
Public ReadOnly Property NumberOfSpectrometers(ByVal measChannelGuid
As Guid, ByVal subsystemIndex As Integer) As Integer
```

measChannelGuid – The GUID of the measurement channel.

subsystemIndex – Thesubsystem index (to specify which of multiple subsystems in the channel).

Remarks: The number of spectrometers in the specified subsystem. If subsystemIndex is not provided, the default index = 0 will be used.

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NumberOfSubSystems

```
Public ReadOnly Property NumberOfSubSystems(ByVal measChannelGuid As Guid) As Integer
```

measChannelGuid – The GUID of the measurement channel.

Remarks: The number of subsystems that compose the specified measurement channel.

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OpticsConfiguration

```
Public Property OpticsConfiguration() As OpticsConfigSystemTypes [Get/Set]
Public Property OpticsConfiguration(ByVal measChannelGuid As Guid) As OpticsConfigSystemTypes [Get/Set]
```

measChannelGuid – The GUID of the measurement channel for which the OpticsConfiguration is to be get/set. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: If the OpticsConfigSystemTypes is not be compatible with the hardware an exception will be thrown.

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OpenSpectrum

```
Public Sub OpenSpectrum(ByVal filenameAndPath As String)
Public Sub OpenSpectrum(ByVal filenameAndPath As String, ByVal measChannelGuid As Guid)
```

filenameAndPath – The full path and filename (including extension) of the spectrum. If the file cannot be opened, an exception will be thrown.

measChannelGuid – The GUID of the measurement channel for a spectrum is to be opened. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: Unlike the behavior when a spectrum is opened in FILMeasure, the software will not automatically analyze the spectrum after opening it. If analysis of the spectrum is desired, then the Analyze function must be called.

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OpenSpectrumFromBuffer

```
Public Sub OpenSpectrumFromBuffer(ByVal theBuffer As Byte())
Public Sub OpenSpectrumFromBuffer(ByVal theBuffer As Byte(), ByVal
measChannelGuid As Guid)
```

theBuffer – Byte array containing spectrum. Data in this array must have been created by SaveSpectrumToBuffer method.

measChannelGuid – The GUID of the measurement channel for a spectrum which is to be opened. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: See remarks after **SaveSpectrumToBuffer**

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RecipeInfo

```
Public ReadOnly Property RecipeInfo() As FIRecipeInfo
Public ReadOnly Property RecipeInfo(measChannelOrSystemGuid) As Guid)
As FIRecipeInfo
```

measChannelGuid - The GUID of the measurement channel associated with a measurement recipe. If multiple measurement channels exist the measChannelOrSystemGuid must be specified.

Remarks: The FIRecipeInfo object contains an assortment of information abou tthe recipe including information about the film stack, if appropriate..

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SaveSpectrum

```
Public Sub SaveSpectrum(ByVal filenameAndPath As String)
Public Sub SaveSpectrum(ByVal filenameAndPath As String, ByVal
ifTextFormatWriteYDataAsPercent As Boolean)
```

filenameAndPath – The full path and filename (including extension) of the spectrum. The file format is determined by the extension. Valid file extensions are the same as the extensions listed in the Save Spectrum dialog windows accessed via the File->Save Measured Spectrum menu item in FILMeasure.

ifTextFormatWriteYDataAsPercent – If this version of SaveSpectrum without this parameter is called, the result is the same as calling the version with this parameter and setting its value to True. Thus, the only reason to call the second variant of the function is if the spectrum is being saved as a text format (either .txt or .csv) and the value of this parameter is set to False

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SaveSpectrumToBuffer

```
Public Sub SaveSpectrumToBuffer( As Byte()
```

Remarks: This function allows the caller to rapidly retrieve the complete set of data contained in a spectrum, thereby avoiding the time that would be consumed if the spectrum were saved to a file. This may be useful in cases where the caller wishes to rapidly acquire a number of spectra and store them up for later saving to file or analysis. The contents of the buffer should be considered opaque. Any changes to the data in the buffer may render the data unusable and/or may not be compatible with future versions of FILMeasure.

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SetAnalysisWavelengthRange

```
Public Sub SetRecipeSetAnalysisWavelengthRange(ByVal
measChannelGuidmeasChannelOrSystemGuid AsGuid, ByVal startWavelength_
nm As Single, ByVal endWavelength_nm As Single)
Public Sub SetAnalysisWavelengthRange(ByVal startWavelength_nm As
Single, ByVal endWavelength_nm As Single)
```

measChannelOrSystemGuid – The GUID of the measurement channel or system. If multiple measurement channels exist, the measChannelOrSystemGuid must be specified (since each measurement channel has its own active recipe).

startWavelength_nm – Starting wavelength for spectrum analysis.

endWavelength_nm – Ending wavelength for spectrum analysis.

Remarks: Setting the wavelength range will also switch the recipe into using a specified wavelength range instead of using the entire wavelength range visible on the spectrum graph.

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SetMaterial

```
Public Sub SetMaterial(ByVal measChannelOrSystemGuid AsGuid, ByVal
layerNumber As Integer, ByVal materialName As String)
Public Sub SetMaterial(ByVal layerNumber As Integer, ByVal
materialName As String)
```

measChannelOrSystemGuid – The GUID of the measurement channel or system. If multiple measurement channels exist, the measChannelOrSystemGuid must be specified (since each measurement channel has its own active recipe).

layerNumber – The layer number for which to modify the material.

materialName – String containing name of the material.

Remarks: You can alter the material of a layer in the current recipe using the method. An exception will be thrown if the layer number is out-of-bounds or the material does not exist.

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SetN

```
Public Sub SetN(ByVal measChannelOrSystemGuid AsGuid, ByVal
layerNumber As Integer, ByVal refractiveIndex As Single)
Public Sub SetN(ByVal layerNumber As Integer, ByVal refractiveIndex
As Single)
```

measChannelOrSystemGuid – The GUID of the measurement channel or system. If multiple measurement channels exist, the measChannelOrSystemGuid must be specified (since each measurement channel has its own active recipe).

layerNumber – The layer number for which to set the refractive index.

refractiveIndex – New refractive index value for layer.

Remarks: You can alter the material of a layer in the current recipe using the method. An exception will be thrown if the layer number or refractive index are out-of-bounds.

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SetRecipe

```
Public Sub SetRecipe(ByVal measChannelOrSystemGuid As Guid, ByVal
recipeName As String)
Public Sub SetRecipe(ByVal recipeName As String)
```

measChannelOrSystemGuid – The GUID of the measurement channel or system. If multiple measurement channels exist, the measChannelOrSystemGuid must be specified (since each measurement channel has its own active recipe).

recipeName – The recipe name to be selected must exist in the list of recipes. Note that you can select recipes contained in subfolders by specifying the relative path, using the backslash character '\' to separate folder names as is conventional in path naming.

Remarks: The current spectrum will not be automatically reanalyzed when a new recipe is selected. To reanalyze the spectrum you must call **AnalyzeSpectrum**.

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SetRoughness

```
Public Sub SetRoughness(ByVal measChannelOrSystemGuid As Guid, ByVal
layerNumber As Integer, ByVal roughness_nm As Single)
Public Sub SetRoughness(ByVal layerNumber As Integer, ByVal
roughness_nm As Single)
```

measChannelOrSystemGuid – The GUID of the measurement channel or system. If multiple measurement channels exist, the measChannelOrSystemGuid must be specified (since each measurement channel has its own active recipe).

layerNumber – The layer number for which to modify the roughness.

roughness_nm – Roughness value which will appear in the Layers tab of the recipe for the specified layer. Units are nanometers.

Remarks: You can alter the roughness of a layer in the current recipe using the method. An exception will be thrown if the layer number or roughness are out-of-bounds.

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SetThickness

```
Public Sub SetThickness(ByVal measChannelOrSystemGuid As Guid, ByVal
layerNumber As Integer , ByVal thickness_nm As Single)
Public Sub SetThickness(ByVal layerNumber As Integer, ByVal
thickness_nm As Single)
```

measChannelOrSystemGuid – The GUID of the measurement channel or system. If multiple measurement channels exist, the measChannelOrSystemGuid must be specified (since each measurement channel has its own active recipe).

layerNumber – The layer number for which to modify the thickness.

thickness_nm – Thickness value which will appear in the Layers tab of the recipe for the specified layer. Units are nanometers.

Remarks: You can alter the thickness of a layer in the current recipe using the method. An exception will be thrown if the layer number or roughness are out-of-bounds.

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SpectrometerDiagnostics

```
Public ReadOnly Property SpectrometerDiagnostics()
AsFISpecDiagnosticsInfo()
Public ReadOnly Property SpectrometerDiagnostics(ByVal
measChannelGuid AsGuid)As FISpecDiagnosticsInfo()
Public ReadOnly Property SpectrometerDiagnostics(ByVal
measChannelGuid As Guid, ByVal subsystemIndex As Integer) As
FISpecDiagnosticsInfo()
```

measChannelGuid – The GUID of the measurement channel.

subsystemIndex – The subsystem index (to select among multiple subsystems in the channel).

Remarks: Returns an array of objects containing information about the spectrometers. Information includes integration time, peak raw signal intensities of reference and background spectra, etc.

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ActivateMonitorDisplayTab

```
Public Sub ActivateMonitorDisplayTab()
Public Sub ActivateMonitorDisplayTab(ByVal measSystemGuid As Guid)
```

measSystemGuid – The GUID of the measurement System. If multiple measurement channels exist, the measChannelGuid must be specified (since each measurement channel has its own active recipe).

Remarks: This function is provided to permit synchronization of the FILMeasure user interface with the user interface of a client program.

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BaselineExistsAndIsAuthenticated

```
Public Function BaselineExistsAndIsAuthenticated(ByRef
authenticationIsPossible As Boolean) As Boolean
Public Function
BaselineExistsAndIsAuthenticated(measChannelOrSystemGuid As Guid,
ByRef authenticationIsPossible As Boolean) As Boolean
```

authenticationIsPossible – If baseline is not authenticated, it is possible to authenticate it when `authenticationIsPossible = True`.

Remarks: In some cases, it is desirable to check whether the baseline is already authenticated and if not whether it is possible to authenticate it. The client software has the option of automatically authenticating the baseline if that is desirable.

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GeneralPurposeIOIsSupported

```
Public ReadOnly Property GeneralPurposeIOIsSupported() As Boolean
```

Remarks: Primary purpose of this property is to permit the example program to hide or show the General Purpose IO controls. This property will be True for equipment that has the General Purpose IO hardware.

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GeneralPurposeIOReadValue

```
Public Function GeneralPurposeIOReadValue() As Byte
```

Remarks: Returns a single byte containing the current values of the general purpose IO logic input signals. Bit value of 1 means that the input voltage is in the logic high state. These input signals are only available on certain types of equipment.

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GeneralPurposeIOSetValue

```
Public Sub GeneralPurposeIOSetValue(newValue As Byte)
```

newValue - New values for the output bits.

Remarks: Sets the output state of the general purpose IO logic output signals. Setting a bit to 1 will set the corresponding output to the logic high state. These output signals are only available on certain types of equipment.

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MeasSystemGuid

```
Public ReadOnly Property MeasSystemGuid(ByVal measSystemIndex As
Integer) As Guid
```

measSystemIndex – The zero-based index of the system.

Remarks: Returns the GUID of the specified system. Note this can be used to obtain the GUID used by all methods requiring a measSystem GUID. Also note that the relationship between measSystemIndex and MeasSystemGuid is not static. Future versions of FILMeasure will dynamically reorder this list in response to an equipment connect/disconnect event. You should not rely on the order of the systems in the list when attempting to perform a command on a certain system.

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MeasSystemGuids

```
Public ReadOnly Property MeasSystemGuids() As Collection(Of Guid)
```

Remarks: Returns a collection of GUIDs containing one item for each measurement system that exists.

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MeasSystemHWName

```
Public ReadOnly Property MeasSystemHWName(ByVal systemGuid As Guid)
As String
```

systemGuid – The GUID of a measurement system.

Remarks: The hardware name is composed of a system name string and a serial number string separated by a colon. Example: F37:09A006

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MeasSystemName

```
Public ReadOnly Property MeasSystemName(ByVal systemGuid As Guid) As
String
```

systemGuid – The GUID of a measurement system.

Remarks: The default system name is the empty string.

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NumberOfSystems

```
Public ReadOnly Property NumberOfSystems() As Integer
```

Remarks: Number of measurement systems that exist.

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SetRecipeModeToSpectrumAnalysis

```
Public Sub SetRecipeModeToSpectrumAnalysis()
Public Sub SetRecipeModeToSpectrumAnalysis(ByVal
measChannelOrSystemGuid As  Guid)
Public Sub SetRecipeModeToThickness()
Public Sub SetRecipeModeToThickness(ByVal measChannelOrSystemGuid As
Guid)
```

measChannelOrSystemGuid – The GUID of one of the measurement channels in a muliple channel system or the GUID of the system. If multiple measurement channels exist, the measChannelGuid must be specified.

Remarks: If Spectrum Analysis recipes are supported by the hardware or add-on licenses, then the Measure tab in the user interface will display a tab control that allows the user to switch modes. The tab associated with the Spectrum Analysis recipe mode is labeled “AR” or “Spectrum”. The other tab is labeled “HC” or “Thickness” or “Thickness, n, k, r”. Calling SetRecipeModeToSpectrumAnalysis or SetRecipeModeToThickness is the same as clicking on the Spectrum or Thickness tab in the user interface.

SetRecipeSpectrumAnalysis

```
Public Sub SetRecipeSpectrumAnalysis(ByVal recipeName As String)
Public Sub SetRecipeSpectrumAnalysis(ByVal measChannelOrSystemGuid As
 Guid, ByVal  recipeName As String)
Public Sub SetRecipeThickness()
Public Sub SetRecipeThickness(ByVal measChannelOrSystemGuid As  Guid,
ByVal  recipeName As String)
```

measChannelOrSystemGuid – The GUID of one of the measurement channels in a multiple channel system or the GUID of the system. If multiple measurement channels exist, the measChannelGuid must be specified.

recipeName – The recipe name to be selected must exist in the list of recipes. Note that you can select recipes contained in subfolders by specifying the relative path, using the backslash character ‘\’ to separate folder names as is conventional in path naming.

Remarks: Same as **SetRecipeModeToSpectrumAnalysis** or **SetRecipeModeToThickness**, but caller specifies name of recipe to load during recipe mode switch.

ShutdownRequestedHandler

```
Public Delegate SubShutdownRequestedHandler(ByVal e As
Windows.Forms.FormClosingEventArgs)
Public Event ShutdownRequested As ShutdownRequestedHandler
```

e – The standard argument type for a form about to close.

Remarks: The client software can prohibit closing of the software by setting `e.Cancel` to `True`. Alternatively, the client software may wish to perform certain actions prior to allowing the FIRemote class to shut down.

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ShuttingDown

```
Public Event ShuttingDown()
```

Remarks: Client software can add an event handler for this event in order to facilitate performing any necessary shut-down actions. This event is primarily used in order to permit client software to react to closing of the FIRemote user interface.

SystemAutoSave

```
Public Property SystemAutoSave() As Boolean
Public Property SystemAutoSave(ByVal systemGuid As Guid) As Boolean
```

systemGuid – The GUID of a measurement system.

Remarks: You can set or get the state of the AutoSave setting using this property. Note that setting a new state for SystemAutoSave will not affect an on-going monitor process, but will take effect the next time a new set of data starts being collected.

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SystemAutoSaveBaseFileNameAndPath

```
Public Property SystemAutoSaveBaseFileNameAndPath() As String
Public Property SystemAutoSaveBaseFileNameAndPath(ByVal systemGuid As
Guid) As String
```

systemGuid – The GUID of a measurement system.

Remarks: You can set or get the base filename and path for the AutoSave file using this property. The full filename is generated by appending a date and time stamp to the base filename. Note that setting a new filename will not affect an on-going monitor process, but will take effect the next time a new set of data starts being collected.

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SystemMeasure

```
Public Function SystemMeasure() As FIMeasResultValuesOnly
Public Function SystemMeasure(ByVal
deleteAccumulatedDataBeforeMeasure As Boolean) As
FIMeasResultValuesOnly
Public Function SystemMeasure(ByVal systemGuid As Guid) As
FIMeasResultValuesOnly
Public Function SystemMeasure(ByVal systemGuid As Guid, ByVal
deleteAccumulatedDataBeforeMeasure As Boolean) As
FIMeasResultValuesOnly
```

deleteAccumulatedDataBeforeMeasure – There is no analog for this parameter in the user interface. Setting this parameter to True causes any existing accumulated data points to be deleted before the measurement is performed.

systemGuid – The GUID of a measurement system.

Remarks: Acquire and measure on all channels in a system. Measurement is performed simultaneously on all channels. Measured results are contained in an FIMeasResultValuesOnly object.

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SystemStartMonitoring

```
Public Sub SystemStartMonitoring()
Public Sub SystemStartMonitoring(ByVal systemGuid As Guid)
```

systemGuid – The GUID of a measurement system.

Remarks: This function starts a monitoring process

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SystemStopMonitoring

```
Public Sub SystemStopMonitoring()
Public Sub SystemStopMonitoring(ByVal systemGuid As Guid)
```

Remarks: This function stops a monitoring process.

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SystemMeasurementCompletedEventHandler

```
Public Delegate Sub SystemMeasurementCompletedEventHandler(ByVal
systemGuid As Guid, ByVal theResults As FIMeasResultValuesOnly)
Public Event SystemMeasurementCompleted As
SystemMeasurementCompletedEventHandler
```

systemGuid – The GUID of a measurement system.

Remarks: This event is raised upon completion of a SystemMeasure task and after each measurement during a SystemMonitor process. You should avoid performing lengthy operations (such as writing data to a file) in the handler for this event because the monitor process will be halted until the handler function exits. If execution of a lengthy operation is needed, you should invoke a different thread to perform the operation. If the event is raised as a result of completing a SystemMeasure task, then you will need to exercise care to avoid creating a threading deadlock. A deadlock will occur if you invoke the thread which called SystemMeasure in the handler for this event because that thread will not return from SystemMeasure until all the event handlers have finished executing. See the FIRemoteTest example program to see one way to avoid the deadlock problem.

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